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OF THE

Mineralogical Society.

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ASSISTED BY A COMMITTEE OF COUNCIL.

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THE MINERALOGICAL SOCIETY

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, February 3, 1903.

Prof. H. A. Miers, F.R.S., Vice-President, in the Chair.

The deaths of the Reverend Professor T. Wiltshire, Ordinary Member, and Professor A. D'Achiardi, Honorary Member, were announced.

Professor Theodor Liebisch, of Göttingen, and Professor Giovanni Strüver, of Rome, were elected Honorary Members of the Society.

GENERAL MEETING.

Held in the Apartments of the Geological Society, February 3, 1903.

Prof. H. A. Miers, F.R.S., Vice-President, in the Chair.

Eleven Members were present. The elections of Professor Liebisch, of Göttingen, and of Professor Strüver, of Rome, to the Honorary Membership were confirmed.

The following papers were read:—

1. On a meteoric stone seen to fall on August 22, 1902, at Caratash, Smyrna: by Mr. L. Fletcher, F.R.S.

2. Note on the history of the mass of meteoric iron found in the neighbourhood of Caperr, Patagonia: by Mr. L. Fletcher, F.R.S.

3. On the crystalline forms of carbides and silicides of iron and manganese: by Mr. L. J. Spencer (p. 296).

4. The refractive indices of Pyromorphite: by Mr. H. L. Bowman (p. 324).

5. Note on Quartz crystals from De Aar: by Mr. T. V. Barker (communicated by Professor Miers) (p. 331).

Professor Maskelyne exhibited some specimens of worked flint implements from Knowle, Wiltshire, having a smooth polish of doubtful origin: also some lustrous black mountain-limestone from Brecon.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, March 24, 1903.

Dr. Hugo Müller, F.R.S., President, in the Chair.

Mr. John Brooke Scrivenor, M.A., F.G.S., of the Geological Survey, was elected an Ordinary Member of the Society.

GENERAL MEETING.

Held in the Apartments of the Geological Society, March 24, 1903.

Dr. Hugo Müller, F.R.S., President, in the Chair.

Nineteen Members were present. The election of Mr. J. B. Scrivenor to the Ordinary Membership of the Society was confirmed.

The following papers were read:—

1. On the Diathermancy of Antimonite: by Dr. A. Hutchinson (p. 342).

2. A peculiar form of Magnetite in Bunter Sandstone: by Mr. J. B. Scrivenor (p. 351).

3. Anatase in the Trias of the Midlands: by Mr. J. B. Scrivenor (p. 348).

4. A large crystal of Sulpharsenite of Lead from the Binnenthal: by Professor W. J. Lewis.

A large, isolated crystal, measuring $4 \times 1 \times \frac{3}{4}$ inch, was shown. The following analysis by Mr. H. Jackson proves it to be sartorite:—Pb, 42·93; S, 25·32; As, 31·11.

5. A twin of Copper-pyrites: by Professor W. J. Lewis.

6. A mineral from the mines of the Borax Consolidated Co., California: by Mr. W. B. Giles (p. 353).

Mr. J. A. Howe exhibited a peculiar stalactite of calcite, and made a suggestion as to the mode of formation.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 9, 1903.

Dr. Hugo Müller, F.R.S., President, in the Chair.

The audited Balance Sheet for the year ending December 31, 1902, was submitted and approved.

The death of Professor A. H. Chester, of New Brunswick, U.S.A., an Ordinary Member of the Society, was announced.

Mr. Herbert Henry Thomas, B.A., F.G.S., of the Geological Survey, was elected an Ordinary Member of the Society.

Mr. Bowman, Mr. H. F. Collins, Dr. Cullis, and Mr. Solly were selected for nomination to replace the retiring Members of Council,

namely, the Earl of Berkeley, Mr. J. H. Collins, Dr. Hutchinson, and Professor Lewis.

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 9, 1903.

Dr. Hugo Müller, F.R.S., President, in the Chair.

Twenty Members and one Visitor were present. The election of Mr. H. H. Thomas to the Ordinary Membership of the Society was confirmed.

The Secretary read a statement relative to a proposal to place a memorial of the late Professor A. D'Achiardi in the Museum of Pisa.

The following papers were read:—

1. Notes on some mineral specimens from Santa Fé, State of Chiapas, Mexico: by Mr. H. F. Collins (p. 356).

2. Observations of the growth of crystals: by Professor H. A. Miers, F.R.S.

The new method of observation consists in tracing the changes of angle upon a crystal during its growth by measuring it at intervals by means of a specially devised inverted goniometer, without moving it from the solution in which it is growing. It was found that an octahedron of alum yielded invariably three images for each face, so that the crystal had really the form of a very flat triakis-octahedron. Similar observations on other crystals lead to the conclusion that the faces of a crystal are in general not faces with simple indices, but vicinal faces slightly inclined to them, which change their inclination during the growth of the crystal. By determinations of the refractive index of the solution by means of total reflection within the crystal, it was found that in each case the liquid in contact with the growing crystal is slightly supersaturated.

The former paper was illustrated by numerous specimens, and the latter by means of lantern slides.

MINERALOGICAL SOCIETY.

ABSTRACT OF RECEIPTS AND PAYMENTS FROM JANUARY 1 TO DECEMBER 31, 1902.

Receipts.	£ s. d.	£ s. d.
Balance from the year 1901		76 2 11
Subscriptions—(1) current	43 1 0	
(2) arrears	10 10 0	
		53 11 0
Entrance fees		3 3 0
Sale of publications by publishers to Dec. 31, 1901		37 7 0
Dividends on Stock		14 2 4
		£184 6 3

Payments.	£ s. d.	£ s. d.
Printing and Stationery (including Authors' copies, £5 1s. 8d.)		55 9 4
Illustrations		7 14 3
Editor's honorarium (1901)		10 10 0
Postage and Parcels		4 2 10
Attendant's Fee at Meetings		1 10 0
Binding	0 1 9	
Commission on P. O. Orders	0 0 3	
Banker's Commission	0 0 6	
		0 2 6
Investments and Brokers' Commission		14 2 4
Balance at Bank	88 6 10	
„ in Office	2 8 2	
		90 15 0
		£184 6 3

Examined and compared with the vouchers, and found correct.
April 30, 1903.

(*Signed*) J. H. COLLINS. H. L. BOWMAN. } Auditors.

Liabilities.	£ s. d.	Assets.	£ s. d.
Owing for Miscellaneous Printing	6 6 3	Balance at Bank	88 6 10
„ George Savigar for postage and care of Stock	1 9 1	„ in Office	2 8 2
„ Secretarial postage	0 5 11	Consols (£558 13s. 1d., valued at £91)	508 7 6
„ Editor's Honorarium (1902)	10 10 0	Balance owing from Publishers	11 11 6
Excess of assets over liabilities	604 19 4	„ „ „ Geo. Savigar for sale of publications	1 5 7
		Subscriptions in arrear	11 11 0
	£623 10 7		£623 10 7

The number of Life Members on December 31, 1902, was 52.

The Stock of Publications and the value of the Library are not included in the above assets.

(*Signed*) W. P. BEALE,
Hon. Treasurer.

April 30, 1903.

THE MINERALOGICAL MAGAZINE

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THE MINERALOGICAL SOCIETY.

No. 62. DECEMBER, 1903. Vol. XIII.

On the advantages of the Gnomonic Projection and its use in the Drawing of Crystals.

(*With a table to facilitate its employment.*)

By G. F. Herbert Smith, M.A., F.G.S.

Assistant in the Mineral Department of the British Museum.

[Read June 10, 1902.]

OF the various methods employed or suggested for the graphical representation on a plane of points on the surface of a sphere, the most important to the crystallographer are the stereographic and the gnomonic projections. Both are in common use, and both have their particular advantages. Professor Penfield has recently published a series of papers[1] in which he points out the advantages that accrue from the employment of the stereographic projection both in crystallography and cartography. He has devised protractors and scales, which facilitate the construction of the projection of the poles of the faces bounding a crystal or of portions of the earth's surface, and enable the angles between points or contained by zones, i. e. great circles, to be readily determined from measurements on the plane diagram. This projection is especially advan-

[1] 'The stereographic projection and its possibilities from a graphical standpoint.' Amer. Journ. Sci., 1901, ser. 4, vol. xi, pp. 1–24, 115–144; abstract, this vol., p. 203. 'On the use of the stereographic projection for geographical maps and sailing charts.' Amer. Journ. Sci., 1902, ser. 4, vol. xiii, pp. 245–275, 347–376; abstract, this vol., p. 306. 'On the solution of problems in crystallography by means of graphical methods, based upon spherical and plane trigonometry.' Amer. Journ. Sci., 1902, ser. 4, vol. xiv, pp. 249–284; abstract, this vol., p. 306.

tageous for use in the construction of maps, because the meridians and parallels are projected as arcs of circles, and are, therefore, easily drawn. We must not, however, overlook the very considerable merits of the gnomonic projection in crystallographical work, especially in the investigation of complicated zonal relations. The author found it of inestimable service in the study of the crystalline development of calaverite [1], but the ordinary method of plotting, such as is described in the textbooks, is awkward, and a projection is not easy of construction. The purpose of this paper is to show that, by means of the table given at the end, the spherical coordinates of any pole may readily be converted into plane coordinates, and, by means of a particular form of protractor, these poles may be plotted on a plane diagram. Further, it will be seen that, with the aid of the table and protractor, the angles between points or contained by zones may be graphically determined on the plane diagram just as in the case of the stereographic projection.

The gnomonic [2] is a perspective projection in which the point of vision is at the centre of the sphere and the poles are projected on to a plane touching it. The point of contact with the sphere, which is the point where the perpendicular from the centre meets the plane, is called the centre of projection. Since the planes of all great circles pass through the centre of the sphere, zones are represented in the projection by straight lines of infinite length. In this property lies the principal advantage of the method; for the zonal relations subsisting between the faces of a crystal are easily tested by means of a straight-edge. This is obviously a simpler criterion than that in the stereographic projection in which three tautozonal poles must lie on the same circular arc, the common chord of which and the primitive circle must be a diameter of the latter. All poles on the great circle whose plane is parallel to the plane of projection are projected to infinity, and hence only a portion of the sphere can be represented on the same diagram. These poles are distant a right angle from the centre of projection, and therefore the angle between any pair is the same as the angle between the zones connecting them with the centre of projection. We can thus represent them by the corresponding zones. This is effected in practice by ter-

[1] This vol., pp. 122–150. A translation appeared in Zeits. Kryst. Min., 1903, vol. xxxvii, pp. 209–234.

[2] For other discussions of this projection see:—'Crystallography; a Treatise on the Morphology of Crystals,' by N. Story-Maskelyne, Oxford, 1895, pp. 492–499. H. A. Miers, 'The gnomonic projection,' Min. Mag., 1887, vol. vii, pp. 145–149. 'Traité de Cristallographie,' by E. Mallard, Paris, 1879, vol. i, pp. 63–66. 'Projection und graphische Krystallberechnung,' by V. Goldschmidt, Berlin, 1887.

minating the diagram by some arbitrary boundary—perhaps the best, a circle—and marking on a similar one outside it the intersections with the lines representing the zones. A projection will not be of inconvenient size which includes all poles lying within an angular distance of about 65° from the centre of projection. Thus on a single diagram we can represent nearly all the faces forming one termination of the crystal and also the faces in the zone of reference. Since the linear distances from the centre of projection are tangents of the corresponding angle, the resulting diagram suffers considerably from distortion, and cannot

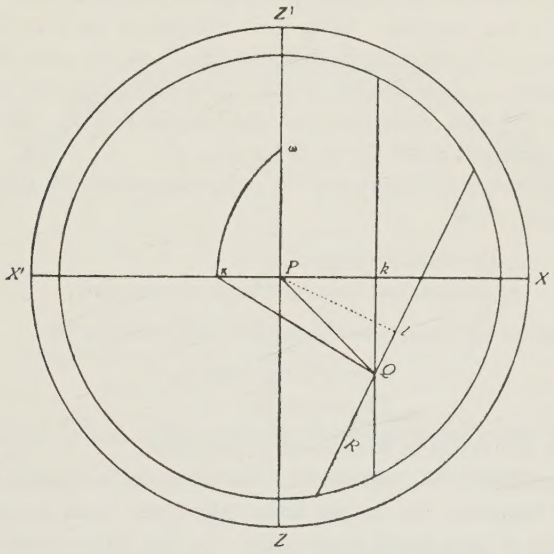


FIG. 1.—Gnomonic projection.

conveniently be used for mapping portions of a sphere. Another disadvantage practically prohibits its employment for this purpose, viz. that parallels of latitude are projected as conic sections, and are only circles in the particular cases when either the north or the south pole is the centre of projection.

Anything like general use of the gnomonic projection has probably been hindered by the difficulty of constructing a diagram from the observations made on a crystal. No difficulty, however, arises if we make use of the methods devised for the measurements of crystals by means of a three-circle goniometer. Measurements are made from poles in a certain zone, known as the zone of reference, as origins, and from

the readings of the circles we obtain for any pole its distance from the origin and its azimuth from the zone of reference. In order to assure the observation of all the faces on the crystal, we should make a systematic survey from one particular origin (including with it the one diametrically opposite). The coordinates thus determined are used for locating the poles of the faces on the diagram, whose plane is taken at right angles to the edge of the zone of reference. All poles in this zone are projected to infinity on the diagram, and consequently all zones passing through the same origin appear as parallel lines.

We may now consider what are the corresponding linear coordinates of a point in the diagram. In fig. 1, P, the pole of the zone of reference, is the centre of projection, and Z the origin on the zone of reference; PX is drawn at right angles to PZ; Q is any point, and Qk is drawn parallel to PZ, and consequently at right angles to PX. Qk is therefore the zone passing through Q and the origin, Z.

If the spherical coordinates of the pole, represented by Q, with respect to the origin, Z, be

ρ, the distance from Z,
ϕ, the azimuth from the zone of reference,

the corresponding linear coordinates are easily seen to be

$$kQ = r \cot \rho \operatorname{cosec} \phi,$$
$$Pk = r \cot \phi,$$

where r is the radius of the sphere of projection.

One coordinate, Pk, representing the azimuth, is readily found from a table of tangents; but as yet either the other must be calculated or the position of Q be found graphically. In the latter method[1] we have successively to find a point ω (fig. 1) in PZ such that $P\omega = r$, the radius of the sphere of projection, and a point κ in PX such that $k\kappa = k\omega$; then the plane angle $Q\kappa k$ is the complement of ρ. Such a method, entailing as it does the use of subsidiary points and lines and of several operations, each liable to error, is exceedingly troublesome to carry out in practice, and may result in considerable confusion and inaccuracy, as, indeed, the author is aware from experience.

At the end of this paper is given a table containing the values of cot ρ cosec ϕ (multiplied by 10 for convenience) for every degree from 90° to 25°. In the columns the azimuths are constant, and in the rows the distances. Since cosec 90° is unity, the first column gives the

[1] Cf. Story-Maskelyne and Miers, loc. cit.

cotangents (multiplied by 10) for every degree, and we may therefore use this column to find the coordinate *Pk*, corresponding to the azimuth.

The use of the table will be made clear from an example. Suppose we wish to locate a pole whose azimuth and distance are respectively 60° 40′ and 55° 10′. Under the column headed 60° we find the value corresponding to 55°; we proceed to subtract the proportionate difference in the column for 10′ and in the row for 40′. Thus we actually obtain 8·09 less 0·05, 8·04, and finally, less 0·05, 7·99. The two plane coordinates are therefore 5·62 and 7·99, multiplied or divided by a constant depending on the length assigned to the radius of the sphere. In

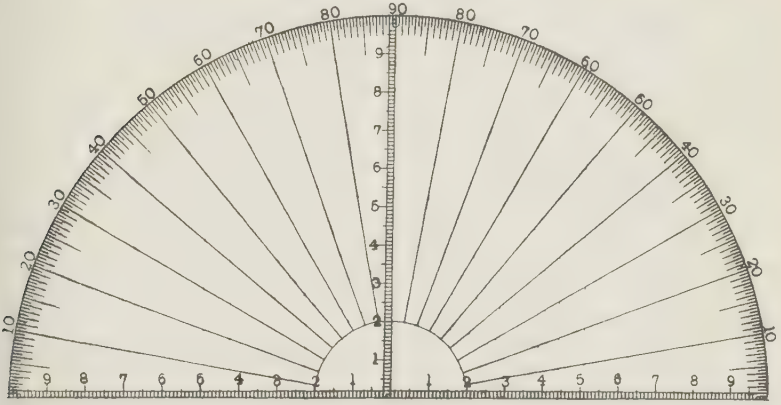


Fig. 2.—Protractor for plotting gnomonic projections.
(Half actual size.)

practice we find the coordinate corresponding to the azimuth first, because there will usually be several poles with the same azimuth. We notice that the plane coordinates increase as the spherical coordinates diminish, and vice versa. All subsidiary work required in the determination of these coordinates may be done on a separate sheet of paper, and the diagram need have no subsidiary lines or points on it at all.

Squared paper, for instance, divided to millimetres, is convenient for plotting the positions of poles, but ordinary blank paper may be used in conjunction with the form of protractor shown in fig. 2. This consists of a strip of celluloid on which is engraved a semicircle. The diameter, which is on the edge of the strip, and the radius at right angles to it are graduated to millimetres. By means of these two scales, mutually at

right angles, we can easily plot the poles from their plane coordinates. To avoid parallax, the engraved side of the celluloid strip should be placed next to the paper. If a pencil be used for plotting, allowance must be made for its thickness. It is perhaps best to use a pin or a needle, which will accurately mark a point just under the edge of the strip. A line must be drawn on the sheet of paper corresponding to PX (fig. 1), and a point marked on it to represent P. Then the protractor is moved about so that the shorter scale lies on this line. The purpose of the graduated semicircle is explained below (p. 316).

In applying the above method to measurements on a goniometer with a single circle, it will be necessary to calculate at least one angle. The majority of the poles may, however, then be located from their positions

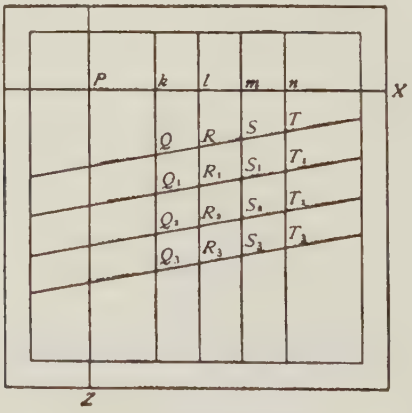


Fig. 3.—Gnomonic projection.

in known zones. In the case of measurements on a goniometer with two circles it may be more convenient to take the centre of projection as origin. In that case the azimuths are the same as the plane angles between the lines on the diagram corresponding to the zones, and the linear distances, e. g. PQ in fig. 1, are proportional to the tangents of the corresponding angle.

We may now proceed to consider a remarkable property of this projection. In fig. 3 we have a series of poles lying in zones passing through the same origin in the zone of reference. Let their azimuths be ϕ, ϕ_1, ϕ_2, ϕ_3. From what has preceded we see that

$$\frac{km \,.\, ln}{kl \,.\, mn} = \frac{(\cot\phi_2 - \cot\phi)(\cot\phi_3 - \cot\phi_1)}{(\cot\phi_1 - \cot\phi)(\cot\phi_3 - \cot\phi_2)} = \frac{\sin(\phi - \phi_2)\sin(\phi_3 - \phi_1)}{\sin(\phi - \phi_1)\sin(\phi_3 - \phi_2)} =$$

a rational quantity, being the anharmonic ratio of a pencil of four crystallographically possible zones, intersecting in the same pole.

Suppose now that $\{T T_1 T_2 T_3\}$ is the zone of reference. Then n lies at infinity, and we are left with the very simple relation

$$\frac{km}{kl} = \text{a rational quantity.}$$

The same relation also holds with regard to poles in a zone, and accordingly we have

$$\frac{QQ_2}{QQ_1} = \text{a rational quantity.}$$

The principal zones in the diagram are thus equally spaced apart, and the same is true of zones passing through any other origin on the zone of reference. The diagram may therefore be divided into a network of equal parallelograms[1], or in special cases rectangles or squares. A necessary consequence follows that the unit linear distances on parallel lines must be the same. This is a most important property, for we have merely to take measurements on the diagram to determine the simple indices corresponding to any particular face.

We will now show that the angles between poles or contained by zones may be graphically determined from the projection with the aid of the protractor and the table.

To find the angle between two poles, represented by points on the gnomonic projection.—Let Q and R (fig. 1, p. 311) be the two points, and P the centre of projection. Place the protractor on the diagram so that the diameter lies along QR, and at the same time the radius passes over P. The zero point then lies on l. Take the readings for P, Q, and R. If necessary, multiply or divide these by a constant quantity, depending upon the length selected for the radius of the sphere of projection. The reading for P gives the length Pl, and from the table the azimuth of the zone QR can be found. Knowing this, we can further find from the table the angular distances corresponding to the observed linear lengths Ql and Rl. The sum or the difference must be taken according as Q and R lie on opposite sides or on the same side of Pl. In the latter case we have the angle required, but in the former the supplement, because the table gives the distance measured from the origin in the zone of reference.

[1] It may be noted that in the triclinic system P will not be a node of the network.

To find the angle between any two zones, represented by straight lines on the gnomonic projection.—Let the zones intersect in D and meet the zone of reference in p_1 and p_2 (fig. 4 *a*). To make the reasoning clearer the corresponding stereographic (fig. 4 *b*) is placed alongside the gnomonic projection. Draw the zone PD and let it meet the zone of reference in d.

Let the angle Dd be ϕ, the angles p_1d and p_2d be the complements of ρ_1 and ρ_2, and the angles p_1Dd and p_2Dd be D_1 and D_2 respectively. Then we have in the triangles p_1Dd and p_2Dd

$$\tan D_1 = \cot \rho_1 \operatorname{cosec} \phi,$$
$$\tan D_2 = \cot \rho_2 \operatorname{cosec} \phi.$$

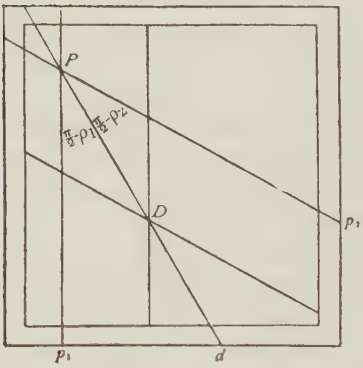


Fig. 4 *a*.—Gnomonic projection.

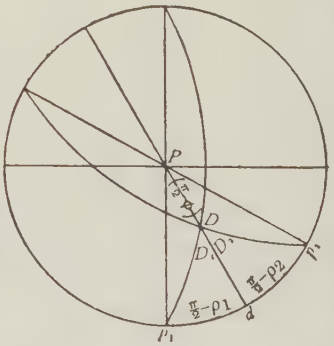


Fig. 4 *b*.—Stereographic projection.

If we now place the protractor on the diagram, so that the zero point is on D and the radius, the reading of which is 90°, passes over the centre of projection, and note the readings of P on the radius scale and those of the two zone-lines on the circular scale, from the first we obtain the length PD, and therefore in the same way as before from the table the angle ϕ, and from the other two we obtain the angles ρ_1 and ρ_2, because the circle is so graduated that the radius, from which we are really measuring, reads 90°. Now the formula given above is the same as that found for the determination of the plane coordinate corresponding to the distance of a pole. We may therefore proceed in the same way. Treating ϕ as an azimuth and ρ as a distance, we get from the table a corresponding quantity, which from the first column we convert into the complement of D_1 or D_2, because this column gives the cotangents. The sum or difference must be taken according as the angles have been

measured on opposite sides or on the same side of PD. As before, we have in the latter case the angle required, but in the former its supplement.

The Representation of Crystals.

Another important property of the gnomonic projection is the facility it affords for drawing crystals in any position. It is customary to suppose the eye sufficiently distant from the crystal for the imaginary lines connecting it to different parts of the crystal to be sensibly parallel. Thus all edges which are parallel on the crystal, i. e. which form the intersections of pairs of faces lying in the same zone, are parallel in the drawing, and the zonal relations are apparent from inspection. Now the edges common to pairs of faces in a zone are parallel to its axis, and in the gnomonic projection zone-planes are represented by straight lines. If we project this axis orthogonally on to the same plane of projection, the line passes through the centre of projection and is at right angles to the zone-line. Hence to prepare an orthographic drawing of a crystal on any plane, we have only to project the poles gnomonically on to the same plane, and the edge common to a pair of faces is given by a line at right angles to the zone-line in which their poles lie.

If the projection be made, as suggested earlier in this paper, so that the edge of some zone is perpendicular to the plane of the paper, the resulting drawing gives a correct idea of the distribution of the faces on the portion of the crystal in view, but the appearance is very flat, because the edges common to pairs of faces in the zone mentioned are represented only by points, and there is a consequent want of solidity. To gain this effect, we must suppose the crystal to be slightly rotated about the vertical and horizontal axes successively in the plane of the paper. The faces, which had previously been at right angles to the plane of the paper, now come into view, and the drawing of the crystal presents the solid appearance desired.

We will now consider how we may determine the positions of the poles after rotation. Suppose we have three rectangular directions fixed in space, OX, OY, OZ (fig. 1), of which OY is perpendicular to the plane of the paper and represented by P, the centre of projection. The crystal is rotated about OZ and OX successively. To take a concrete instance, let us suppose these rotations are 20° and 10° respectively, and consider the effect on a pole whose azimuth and distance from Z are 38° 35′ and 49° 26′ respectively, the rotation increasing the

azimuth in each case. After the first rotation these become 58° 35′ and 49° 26′, the latter of course being unaltered. We now have to find the new spherical coordinates with respect to X. From the table we find that the plane coordinates with respect to Z are 6·11 and 10·03; with respect to X therefore they are 10·03 and 6·11, or in spherical coordinates 44° 55′ and 66° 38′. After rotation of 10° about OX we have the coordinates, 54° 55′ and 66° 38′, and obtain from the table the corresponding plane coordinates, 7·03 and 5·28. Reversing these, we find that the coordinates which were 12·54 and 13·73, corresponding to 38° 35′ and 49° 26′, are now 5·28 and 7·03. These must be multiplied or divided by a constant depending on the length assigned to the radius of the sphere. Since for the purpose of delineation extreme accuracy in the position of the poles is not essential and the projection should be as compact as possible, 2 cm. will be a convenient length to give to this radius, and the coordinates after rotation are therefore 1·06 and 1·41 cm. parallel to PX and PZ respectively. In practice we should make the transformations on a separate sheet of paper in the following way:—

		Azimuth	Distance	
Before rotation	plane coordinates	12·54	13·73	Measured from Z
	spherical ,,	38° 35′	49° 26′	
After first rotation (20° about OZ)	,, ,,	58° 35′	,, ,,	
	plane ,,	6·11	10·03	
	spherical ,,	44° 55′	66° 38′	Measured from X
After second rotation (10° about OX)	,, ,,	54° 55′	,, ,,	
	plane ,,	7·03	5·28	
	,, ,, ($r=2$ cm.)	1·41 cm.	1·06 cm.	

After plotting a few poles we may determine the positions of the remainder with sufficient accuracy as the intersections of zones. Four poles, no three of which are tautozonal, are theoretically enough; but it is advisable to plot a few more as a check on the accuracy of the work.

This method applies equally well to all systems. In plotting *ab initio*, the edge of some zone is taken perpendicular to the plane of the paper. Where possible, it would naturally be the zone whose edge in the resulting drawing is most foreshortened, so that the rotations which have first to be applied are not large. If this zone is [100,001], the face (010) is represented by P in all systems save the triclinic. When the axes are at right angles, the faces (100) and (001) would naturally be represented by X and Z. In any system we should plot the new posi-

tions of the faces (010), (110), ($\bar{1}$10), (011), (01$\bar{1}$), (111), ($\bar{1}$11), (11$\bar{1}$), ($\bar{1}$1$\bar{1}$). These would suffice to give accurately the positions of the initial zone-lines, and the remainder may be determined by graphical construction. In the general case, in which these particular poles are not for some reason available, we select in the most convenient way eight poles, which lie by pairs on four zone-lines intersecting in a ninth.

Since the rotations are usually not large, it will not be possible to plot on a sheet of convenient size the poles representing faces in the zone, whose edge was originally perpendicular to the plane of the paper, unless the radius of the sphere is taken too small. For instance, if we employ the rotations suggested by Haidinger, namely, 18° 26′ and 7° 11′, the distances of (001) and (100) from the centre of projection after rotation, assuming that these poles originally coincided with Z and Y, are 7·9 r and 3·0 r, where r is the radius of the sphere. We can, however, easily obtain the direction of the edge common to the faces lying in this zone in another way. P is its pole in the altered position. If P' be the new position of P, PP' will be the orthogonal projection of the axis of the zone, and therefore gives the direction of the edge in question. Other zone-lines passing through poles on this zone may be determined by means of poles on them, which are located in accessible portions of the diagram.

We can further determine from the gnomonic projection the proper length on the drawing for any edge. It is the actual length on the crystal multiplied by the sine of the angle it makes with the normal to the plane of the paper. This angle is the same as the azimuth of the zone, whose axis is parallel to the particular edge, as given earlier in this paper (p. 312). Hence if we know the actual length of any edge we can readily find its projected length. This is a very useful check on the accuracy of the work.

In this method twin crystals present no greater difficulties than simple crystals. The poles of corresponding faces on the two individuals lie on a line passing through the pole of the twin-axis and make equal angles with it. We have shown above how to find the angle between the faces represented by two points. After plotting a few poles in this way, the remainder may as before be determined from the intersections of zones.

The method here described is precisely the same as that of Mohs and Haidinger[1] as regards the resulting drawing; but these authors obtain

[1] Haidinger, 'Account of the method of drawing crystals in true perspective, followed in the Treatise on Mineralogy of Professor Mohs.' Mem. Wernerian Soc. Edinburgh, 1824-5, vol. v, pp. 485-508.

the directions of the edges in another way. The projections of the three fundamental axes and the unit intercepts made on them have first to be determined. This is a troublesome process *ab initio*. In practice a crystallograph is used, an instrument consisting of three coplanar arms inclined to one another at the proper angles and graduated according to the several projected unit lengths. For the cubic system we have at once the fundamental factors required; for any other system we must introduce modifications, maybe only in the units, but in the case of the monoclinic and triclinic systems in both units and angles. The determination of the fundamental factors for the second individual of a twin presents considerable difficulties. When we have at length drawn the axes and marked off the unit lengths on each, we find the position of any face from the relative intercepts it makes on the axes. If we suppose two faces meet one axis in the same point, the direction of the common edge is given by the line connecting this point to the intersection of the two lines, belonging to each face, which join the points where they meet the other axes. In practice many difficulties and possibilities of error arise. If the crystal is at all complicated, confusion may occur from multiplicity of lines that must be drawn for the determination of the various edges. We have further to remember, that an intercept is derived directly not from the corresponding index, but from its inverse; and we must be careful of the signs. None of these difficulties are encountered if the gnomonic projection be employed to give the directions of the edges. Then, again, in this method we may select the rotations most suitable for displaying the symmetry of the faces and their disposition on a crystal. If a crystallograph be used, we are confined to particular angles, usually those suggested by Haidinger, namely, $\tan^{-1}\frac{1}{3}$ (18° 26′) and $\sin^{-1}\frac{1}{8}$ (7° 11′).

Another method frequently employed is that of Naumann[1], which only differs from the preceding in that the paper is supposed to move with the crystal in the second rotation, or, as Naumann expresses it, the eye moves up[2]. The paper is now inclined to the line of sight and the projection is clinographic. Its principal recommendation is the simple practical rule[3] whereby the projections of the axes and the unit intercepts on each may be determined; otherwise it has no superior merits, and the after-procedure is precisely the same as in the orthographic method.

To illustrate the method described above, a combination of the cube,

[1] 'Lehrbuch der reinen und angewandten Krystallographie,' Leipzig, 1830, vol. ii, pp. 400–483. [2] Loc. cit., p. 401. [3] Loc. cit., p. 403.

TABLE FOR USE IN PLOTTING GNOMONIC PROJECTIONS.

By G. F. Herbert Smith, M.A.

(*Mineralogical Magazine*, No. 62, Vol. XIII, 1903.)

Cosecant Azimuths.

Cosecant Azimuths.

Cotangent Distances.

Cotangent Distances.

	90°	89°	88°	87°	86°	85°	84°	83°	82°	81°	80°	79°	78°	77°	76°	75°	74°	73°	72°	71°	70°	69°	68°	67°	66°	65°	64°	63°	62°	61°	60°	59°	58°	57°	56°	55°	54°	53°	52°	51°	50°	49°	48°	47°	46°	45°	44°	43°	42°	41°	40°	39°	38°	37°	36°	35°	34°	33°	32°	31°	30°	29°	28°	27°	26°	25°	
90°	0·00	0·00	0·00

octahedron, and dodecahedron is drawn in fig. 5. We first draw the gnomonic projection with the pole of a cube face coincident with the centre of projection. In the actual drawing the radius of the sphere was given a length of 2 cm. We now give the system rotations of 20° and 10° about the vertical and horizontal axes, respectively, in the plane of the paper, as shown in the figure, and obtain another projection.

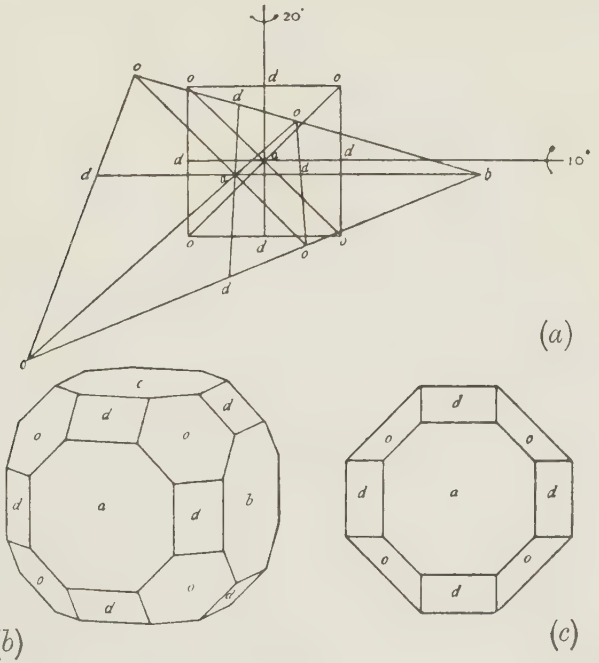


FIG. 5.—Plan (*c*) and orthographic drawing (*b*) derived from the gnomonic projection (*a*) of a crystal.

From these projections we prepare drawings of the crystal in the two positions. The drawings represent crystals of exactly the same size, the lengths of the projections of the various edges having been calculated in the manner described above.

The table appended to this paper gives the values of $10 \cot \rho \operatorname{cosec} \phi$ for every degree from 90° to 25°, where ρ and ϕ represent the distance and azimuth of a pole measured from an origin in the zone, whose edge is at right angles to the plane of the paper, the azimuth being measured from this zone. The purpose of the table is explained above (p. 313).

Communications from the Oxford Mineralogical Laboratory, No. VI.

1. Note on Mica (Fuchsite) as a decorative stone used by the ancients: by Professor H. A. Miers, F.R.S.

2. Note on the Refractive Indices of Pyromorphite, Mimetite, and Vanadinite: by H. L. Bowman (p. 324).

2. Note on some rare twins of Calcite from Somerset: by H. L. Bowman (p. 329).

4. On some crystals of Quartz from De Aar (Cape Colony) and other localities: by T. V. Barker (p. 331).

Note on Mica (Fuchsite) as a decorative stone used by the ancients.

By Professor H. A. Miers, F.R.S.

[Read March 25, 1902.]

THE specimen to which the following note refers was found in the Oxford Collection, and nothing is known of its origin.

It is a polished piece of translucent emerald-green stone, with patches of darker green and also patches of a dull brown colour.

The stone has taken a high polish, and brilliant internal reflections from immediately below the surface of the paler portions give it in those parts almost the appearance of a flawed emerald. But the fractured surface shows it to be merely a massive, pale green, micaceous mineral with brown patches, which appear at first sight to be only an iron-stained variety of the same substance.

The fragment is a portion of the right leg of a statuette of a nude figure, and of excellent workmanship; it is three inches in length, and extends from the hip to the knee; holes bored into the two ends indicate that the statuette was composed of small segments joined together, and suggest that the material could not be obtained in larger pieces.

I have never seen any decorative or sculptural work in which this material has been used, neither have the archaeologists to whom I have shown it. They unite, however, in attributing the work to a Roman artist and to the best period.

It is unfortunate that the rest of the statuette has disappeared, for it would have been interesting both on account of its material and its workmanship.

The mineral appears to be a pale green mica, consisting of small plates; cleavage flakes examined under the microscope yield an axial angle of about 70°, and a negative bisectrix not quite perpendicular to the cleavage. The specific gravity (in the mass) is 2·84.

Blowpipe tests show the presence of chromium, so that the mineral is to be referred to chrome-mica or fuchsite.

Examined under a high power, the brown patches are found to owe their colour to minute included crystals, some twinned, and some simple, which have the characteristic form of rutile or zircon. Since they exhibit also lamellar twinning and do not give an absorption-spectrum, they are probably rutile.

The chief interest of the specimen is really archaeological; and this note is published with the object of directing the attention of mineralogists to the ancient use of this material as an ornamental stone, in the hope that they may see and identify similar specimens elsewhere. A polished piece showing no fracture would scarcely be identified as mica except by one who had seen this specimen or read a description of it. The substance is so beautiful when polished, and takes such a good surface, that it was probably a highly valued material. It has occurred to me that it may very possibly be one of the stones which received the name of emerald among the ancients.

Pliny distinguishes no less than twelve varieties of smaragdus; and it is quite clear that the name was applied to a number of green minerals. One variety in particular he describes in the following words[1]: 'Chalcedonii nescio an in totum exoleuerint, postquam metalla aeris ibi defecerunt; et semper tamen viles fuere, minimique. Iidem fragiles, sed colore incerti, et virentium in caudis pauonum columbarumque collo plumis similes, ad inclinationem magis aut minus lucidi, venosi quidem squamosique. Peculiare erat in his vitium sarcion appellatum: hoc est, quaedam gemmae caro. Mons juxta Calchedonem, in quo legebantur, Smaragdites vocatus est.'

Here the flaky structure, the iridescence or internal reflections, and the brown stain may all very well relate to a mineral similar to the one described in this note. That it had been brought from the neighbourhood of copper mines would suggest that it may have been a mineral

[1] 'Historia Naturalis,' Liber XXXVII, 18.

which derived its green colour from copper; but this is by no means necessary.

King [1] identifies the chalcedonian smaragdus with 'crystals of transparent Chrysocolla,' an identification which will hardly recommend itself to mineralogists. Corsi [2] had supposed it to be the amazon-stone.

The use of fuchsite for decorative purposes in prehistoric times has been noted by Max Bauer [3], who found pierced beads from Guatemala to consist of this material.

Note on the Refractive Indices of Pyromorphite, Mimetite, and Vanadinite.

By H. L. Bowman, M.A.

[Read February 3, 1903.]

IT is somewhat remarkable that a group of minerals, of which such excellent transparent crystals are known as of pyromorphite, mimetite, and vanadinite, should not have hitherto been submitted to a detailed optical examination, except as regards the nature of the interference figures visible in a cross-section. The only reference to the refractive indices of these substances, which I have been able to find, is one by Schroeder van der Kolk [4], who states that those of pyromorphite and vanadinite are above 1·93 (as found by immersion in highly refracting liquids), and that they have a birefringence of 0·02 and 0·01 respectively.

The object of the present note is to record the results of some determinations of the refractive indices of the three minerals, made with material in the Oxford Museum from various localities, by means of the prism method.

Unfortunately the angle (60°) between alternate natural faces of the

[1] 'Natural History of Precious Stones and Metals,' 1883, p. 288.
[2] 'Delle Pietre Antiche,' Roma, 1828, p. 170.
[3] Centralblatt f. Mineralogie, 1900, p. 291.
[4] Zeits. anal. Chem., 1899, Jahrg. xxxviii, p. 656.

hexagonal prism is too great to admit of the determination being carried out by their means, and so the following measurements have been made with prisms having at least one face artificially ground and polished, except in one case, in which, owing to the occurrence of faces of both $m\{10\bar{1}0\}$ and $a\{11\bar{2}0\}$, a convenient prism of 30° was available. The prisms used had in every case their edge parallel to the vertical axis of the crystal. They were made by grinding with oil on a sheet of ground glass (the crystal being cemented to a simple form of guide, which ensured the flatness of the faces), and were polished with putty-powder.

The exact position of the vertical axis within the crystals was somewhat uncertain owing to the striated and uneven character of the natural prism-faces, which frequently do not fall accurately into a zone, and a measurement of the angles between the ground faces and the basal plane (where present) was used to determine the accuracy of the orientation of the prisms, although this face also generally gave a blurred or multiple image in the goniometer.

Since, in a uniaxial crystal, any prism whose vertical bisecting plane contains the optic axis, will give the true values of ϵ and ω in the position of minimum deviation, any error (in ϵ) due to faulty cutting will depend only on the inclination of the optic axis to the plane bisecting the prism-angle. This inclination (θ) is given below for the various prisms, and (except in two cases) does not exceed $\frac{1}{2}$°—an amount which will scarcely affect the value of the index[1].

In the biaxial varieties the indices given under ϵ will correspond to α, while those given as ω will have a value intermediate between β and γ.

The indices were determined by the method of minimum deviation, for light of three colours, using—

Red glass,
Sodium flame,
Blue glass.

The last is a combination of a plate of 'signal green' with one of flashed blue glass, devised by H. G. Madan[2]. From the spectrum of direct sunlight it absorbs the whole of the red end as far as *b*, with the exception of a narrow band in the green, midway between D and E. The whole of the blue is transmitted, the brightest part being slightly beyond F. In most cases the source of light used was a Welsbach mantle, and the green

[1] If the true value of ϵ be calculated from the observed indices and θ, the result obtained in the worst case (No. 4) does not differ from the observed value by so much as one in the fourth place of decimals.

[2] Nature, 1885, vol. xxxi, p. 263.

image was not seen; but in one case, with the electric arc, it was visible, and the corresponding indices are given (prism No. 2). The red glass transmits a well-defined band, whose centre is close to C.

Repeated readings for the deviation-angles were as a rule fairly concordant—the extreme values differing from the mean by less than 6′ to 7′—but in two cases the difference reached as much as 13′ (No. 1, ω_{Blue}) and 14′ (No. 4, ϵ_{D}). The maximum error possible in the refractive index (as compared with that calculated from the extreme readings) would then be 0·004, but the actual error is probably much less than this.

The values for red are the most reliable, while those for blue are the least certain, owing to want of light and the rather wide range of colour of the blue glass.

The material used for the various determinations is described below, and the results are collected in the table, p. 328.

It will be seen from the table that the substitution of arsenic for phosphorus, and of vanadium for arsenic, in each case causes an increase in the refractive indices.

(1) *Pyromorphite* from Braubach, Nassau.

A prism with two ground faces at 32° 17′[1], from a pale liver-coloured crystal (hexagonal prism with flat ends; forms[2]: *m*, *c*, *a*, *x*; *m* and *x* bright, *a* and *c* dull). $\theta = 0° 12'$[3].

This is a pure pyromorphite, and contains no arsenic or fluorine. On analysis it gave the following figures:

PbO	81·12
FeO (or Fe_2O_3) . . .	trace
P_2O_5	16·51
Cl	2·71
Ba, Ca	traces
	100·34
Less O for Cl . .	0·61
	99·73

[1] Each of the two faces gave two equally good images of the goniometer-signal 4′ apart. The prism-angles corresponding to these images are 32° 13′, 32° 17′, 32° 21′. The effective refracting angle is here taken as the mean (= 32° 17′). The difference in the refractive index caused by taking one of the extreme values would be about 0.0024.

[2] The lettering of the forms is that used by Dana (System, 1892), viz.:—*a* $\{11\bar{2}0\}$, *m* $\{10\bar{1}0\}$, *c* $\{0001\}$, *y* $\{20\bar{2}1\}$, *x* $\{10\bar{1}1\}$, *u* $\{21\bar{3}1\}$, *s* $\{11\bar{2}1\}$.

[3] θ = inclination of the optic axis to the plane bisecting the prism-angle.

A cross-section of another similar crystal showed a uniform negative uniaxial figure over its whole area, with the exception of a narrow zoned border, which showed wavy extinction and (in places) a narrow-angled biaxial figure, with the axial plane at 90° or at 60° to an edge of the hexagon.

(2) *Mimetite* from Wheal Alfred, Cornwall (?).

A small crystal (1 mm. long), of a pale yellowish green colour, of unknown origin, but probably from Wheal Alfred. It shows the prism *m*, with two faces of *a*, and is terminated by *x* and a minute basal plane. The prism used was a natural one of 29° 58′ formed by a pair of plane and brilliant faces belonging to *a* and *m*.

(3) *Mimetite* from Wheal Alfred (?).

A prism of 36° 2′, with two ground and polished faces, made from a larger crystal off the same specimen as (2). Forms: *m*, *x*, *c*. $\theta = 0° 37'$.

(4) *Mimetite* from Wheal Alfred (?).

A pale green prismatic crystal with basal plane, having a bright yellow band at the free end. Locality uncertain, but probably Wheal Alfred. Forms: *m*, *c*, *y*, *x*. This must be referred to mimetite, as a small fragment (chiefly of the green material) showed only a trace of phosphoric acid.

The prism used had two ground faces at 30° 14′. $\theta = 1° 40'$.

A section (0·6 mm. thick) of the yellow end-material, cut perpendicular to the axis, shows a complex lamellated structure, and only extinguishes in places, in which traces of a negative biaxial figure are visible, having an axial angle $2E = 62°$, the axial plane being parallel to one or other of the sides of the hexagonal section. The lamellae appear to make an angle of about 40° with the hexagon-sides.

(5) *Mimetite* from Tintic District, Utah.

A prism of 30° 36′ with ground faces, from a slender, white, striated, hexagonal needle with broken ends. A natural prism-face is 40′ out of the zone of the two ground planes between which it lies.

Another crystal from the same specimen shows *m*, *x*, *c*.

A cross-section of a similar crystal shows a division into sectors and indistinct zonal structure. The sectors extinguish at 60° to the edges of the hexagon, and show a wide-angled negative bisectrix, with the axial plane in the same direction.

This specimen is a pure mimetite, being free from phosphoric acid.

	Red (C)			Yellow (D)			Blue (F)		
	ϵ	ω	$(\epsilon-\omega)$	ϵ	ω	$(\epsilon-\omega)$	ϵ	ω	$(\epsilon-\omega)$
(1) Pyromorphite (Braubach)	2·042	2·0504	−0·0084	2·0494	2·0614	−0·0120	2·0832	2·0964	−0·0132
(2) Mimetite (Wheal Alfred?)	2·1236	2·1392	−0·0156	2·1346	2·1488	−0·0142	Green (D-E) 2·173) Blue (F) 2·2053	2·1891 2·2220	−0·0161 −0·0167
(3) Mimetite („ „)	2·1180	2·1349	−0·0169	2·129	2·144	−0·015	2·1762	2·1915	−0·0153
(4) Mimetite („ „)	2·1178	2·1344	−0·0166	2·129	2·1475	−0·0185	—	—	—
(5) Mimetite (Tintic)	2·1178	2·1326	−0·0148	2·1286	2·1443	−0·0157	2·1750	2·1932	−0·0182
(6) Endlichite (Hillsboro')	2·292	2·341	−0·049	2·311	2·358	−0·047	—	—	—
(7) Vanadinite (Tucson)	2·299	2·354	−0·055	—	—	—	—	—	—

It is probably similar to the material from the Richmond Mine, Eureka, Nevada, analysed by Massie[1].

(6) *Endlichite* from Hillsboro', New Mexico.

A prism of 31° 3′ with two ground faces, cut from a pale yellow hexagonal prism (2·5 mm. diam.) with basal plane and narrow faces truncating the vertical edges. The basal plane gave several images, and the angles from it to the ground planes varied between 89° 51′ and 90° 30′ and between 89° 35′ and 90° 7′. Taking the mean values, $\theta = 0° 11'$. The natural prism-faces do not fall into a zone.

A cross-section (0·8 mm. thick) of another crystal from the same specimen, does not extinguish in any position, but shows in places a banded structure, suggesting zones of varying composition. Most of the section shows a normally emergent negative bisectrix ($2E = 14°$). The axial plane varies in position in different parts of the section, being in some places parallel to a face of a hexagonal prism, and in others inclined to it at various angles.

(7) *Vanadinite* from the Old Mammoth Mine, Tucson, Arizona.

A prism of 21° 10′ with one ground and one natural face, from a dark ruby-red crystal (hexagonal prism with flat ends, *m*, *c*, *u*). [Some other crystals off the same specimen show *m* and *c*, narrow *x*, and minute planes of *u*, *s*.] $\theta = 0° 24'$.

The indices were determined for the nearly monochromatic red light transmitted by the crystal, which lies between the lines C and D.

The crystal is markedly pleochroic, the colours being :—

ω brownish-red.

ϵ brownish-yellow.

Note on some rare twins of Calcite from Somerset.

By H. L. Bowman, M.A.

[Read February 4, 1902.]

THE crystals to which this note refers, occur in a quarry in the New Red Sandstone at Bindon, in Somerset, on the property of Mr. H. H. Worthington, and were presented to the Oxford Museum a few months ago by his son, Mr. J. H. Worthington. I have lately had an opportunity of visiting the locality and examining the mode of occurrence of the specimens.

[1] Chem. News, 1882, vol. xlvi, p. 215.

The crystals have all been obtained from a single, roughly vertical vein in the side of the quarry, which shows an exposure of irregularly alternating beds of red sandstone and conglomerate. The pebbles of the latter consist, for the most part, of a compact purplish limestone, while a few are of greasy-looking quartz. The vein is at present traceable to a vertical height of about nine feet from the floor of the quarry, and has an average width of about six inches, but in some places it is much narrower and filled up with masses of calcite.

The crystals are thickly scattered over both walls of the vein, and are of two sizes, the larger being uniformly twins of the habits shown in figs. 1 and 2, and usually about one inch in thickness, and as much

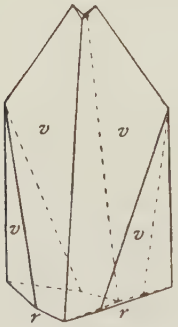


FIG. 1.

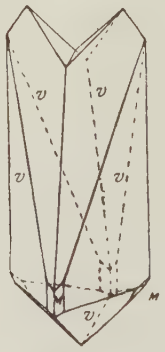


FIG. 2.

Calcite from Somerset. Twin-plane f (11$\bar{1}$).

as two inches long. These are sometimes accompanied by smaller, rounded-scalenohedral crystals, about $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter, which are not twinned. The crystals are enveloped in red clay, of which they enclose portions, and are thereby stained red.

The interest of the occurrence lies in the twinning, which takes place according to the rarest of the twin-laws of calcite, the twin-plane being the face f (11$\bar{1}$).

The faces of the crystals are dull, and often pitted and cavernous, but measurement of good specimens with the contact-goniometer shows the main scalenohedron to be the common form v {20$\bar{1}$}, while one doubly terminated specimen (fig. 2) shows also faces of a steep direct rhombohedron, probably M{3$\bar{1}\bar{1}$} [Dana's {40$\bar{4}$1}]. The crystals are commonly attached by one end to the matrix, and when broken off show a pair of cleavage-planes forming an obtuse (salient) angle of 35$\frac{1}{2}$° (fig. 1). One crystal gave on measurement 35° 30′, the theoretical angle being 35° 27′.

On some crystals of Quartz from De Aar (Cape Colony) and other localities.

By T. V. Barker.

[Communicated by Professor Miers, and read February 3, 1903.]

A SMALL set of quartz crystals of somewhat peculiar habit, collected by Lieut. E. G. Spencer-Churchill near De Aar, South Africa, and given by him to the Mineral Department of the University Museum, present some features of interest; two crystals, in particular, are remarkable as exhibiting faces seldom observed on quartz. The first has a face X lying in the zone $[mz]$ (or $[mr]$?), the other a well-developed face in the zone $[rz]$.

The crystal bearing the former face, X, is depicted in fig. 1. As regards habit and other features, it is in all respects similar to the second crystal (fig. 2).

The faces r and z cannot be distinguished with certainty, but cleavage-cracks within the crystal point to the lettering shown in fig. 1. The polariscope proves the presence of both right- and left-handed material.

The face X gave on the goniometer two indifferent images (X_1, X_2), neither of which could be preferred to the other; the measured angle leads to the indices $(77\bar{5})$ and $(33\bar{2})$ if the faces are below z, or to $(11.\bar{1}.\bar{1})$ and $(14.\bar{1}.\bar{1})$ if they are below r. All four faces have been found by Des Cloizeaux on crystals from Traversella.

	Angle to m. Observed.	Calculated.	Miller.	Bravais.	Des Cloizeaux.
X_1	30° 14′	30° 34′	$(77\bar{5})$ or $(11.\bar{1}.\bar{1})$	$(\bar{4}40\bar{3})$ or $(04\bar{4}\bar{3})$	$e^{\frac{5}{7}}$ e^{11}
X_2	32° 13′	32° 12½′	$(33\bar{2})$ or $(14.\bar{1}.\bar{1})$	$(\bar{5}50\bar{4})$ $(05\bar{5}4)$	$e^{\frac{3}{5}}$ e^{14}

The other crystal is exhibited in fig. 2. The habit is slightly tabular parallel to r. The crystal is somewhat smoky and contains liquid inclusions, one of which shows a bubble. The surface is much corroded. There is no marked cleavage, and the crystal does not exhibit any s-faces. It is therefore not possible to identify r and z. On immersion in oil and examination in convergent polarized light, the crystal exhibits Airy's spirals, and is therefore an interpenetration-twin of right- and left-handed

material; the right-handed portion, however, appears to predominate. The lower end of the crystal is broken.

There is a single face on an edge [rz], which lies to the left of a rhombohedron-face, and corresponds to d_4 (13.$\bar{1}$.2) (13.11.$\bar{14}$.14) or to its inverse (11.31.22) (3.11.14.14). Measurement of the angle between this face, which is slightly rounded and gives a small band of images,

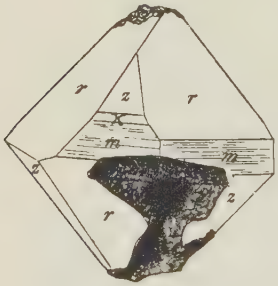


FIG. 1.

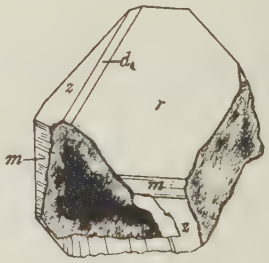


FIG. 2.

Quartz crystals from De Aar, Cape Colony.

and the rhombohedron-face, r or z, gave, as the mean observed value, 9° 30′, the corresponding calculated value being 9° 25′.

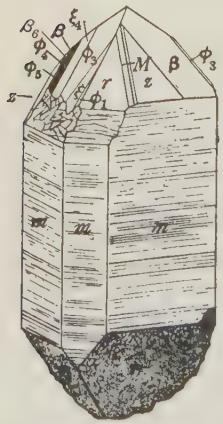


FIG. 3.—Quartz. (Locality unknown.)

The face d_4 was first observed by Websky[1] on a crystal of unknown origin; on this crystal, too, it was not accompanied by any other face of this series. The inverse form does not appear to have been observed.

The other crystals from this locality contain liquid inclusions, in small spaces which are either negative crystals or flattened cavities; and the crystals, when broken, yield a smell somewhat resembling that of petroleum.

On examining other crystals in the Oxford collection, one of unknown locality was found, also showing faces in the zone [rz]. It is depicted in fig. 3. The lower end of the crystal is broken away by cleavages parallel to the rhombohedron r; the m-faces are horizontally striated. The face s is present (at the back of the crystal), and its

[1] Ann. Phys. Chem. (Poggendorff), 1856, vol. xcix, p. 296.

position with respect to r proves the crystal to be left-handed. To the left of z, at M in the figure, there is a re-entrant angle. The r-faces are smooth, the z-faces rough. The lower end of the crystal is opaque, so that optical observations were not possible without mutilation.

The zones $[rz]$ are corroded, some of the corrosion-faces giving distinct images, while there is also a band of images approximating to a face β (20.$\bar{7}$.14). The faces occur on two edges $[rz]$—A and B, and the measured angles between them and r are given in the following table, together with the corresponding calculated angles and indices. The angles are calculated for an axial ratio $a:c = 1:1{\cdot}09997$ ($rr' = 85°\ 46'$).

Face.	$(hkl):100$. Observed.	$(hkl):100$. Calculated.	Miller.	Bravais.
	On the edge A.			
	° ′	° ′		
ϕ_1	13 48	13 50	121.$\bar{1}$4.28	14.31.$\bar{4}$5.45
ξ	22 52	23 8	5$\bar{1}$2	11$\bar{2}$2
ϕ_3	27 44	27 43	77.$\bar{1}$9.38	19.13.$\bar{3}$2.32
ξ_4	33 38	33 30	16.5.10	5$\bar{2}$77
A band of faces	35 5 to 38 13	35 11 38 14	3$\bar{1}$2 83.3$\bar{1}$.62	3$\bar{1}$44 31.7.$\bar{3}$8.38
β (centre of the band)	36 39	36 29	20.$\bar{7}$.14	7$\bar{2}$99
β_6	43 40	43 38	11.5.10	15.1.$\bar{1}$6.16
ϕ_4	44 49	44 46	19.9.18	27.1.$\bar{2}$8.28
ϕ_5	45 29	45 28	35.$\bar{1}$7.34	51.1.$\bar{5}$2.52
	On the edge B.			
ϕ_3	27 46	27 43	77.$\bar{1}$9.38	19.13.$\bar{3}$2.32
A band of faces	34 27	34 27	149.$\bar{4}$7.94	141.55.$\bar{1}$96.196
	37 26	37 26	257.9$\bar{1}$.182	91.25.$\bar{1}$16.116

It is noteworthy that we have a band of images about β in both cases. ξ was first observed by Des Cloizeaux, ξ_4 by Gonnard, β by Des Cloizeaux, and β_6 by Gonnard.

The crystal appears to be very similar to some described by Lacroix [1], in which the surfaces between r and z were curved and gave sometimes separate images, sometimes groups of images. Thus on a crystal from Allevard in the department of Isère, he found images indicating faces inclined to r at angles varying between the values 9° 30′ and 11° 0′; also between 22° 0′ and 27° 2′: finally, the faces β_1 (3$\bar{1}$2) and β_6 (11.$\bar{5}$.10) gave distinct images. Again, a crystal from La Gardette showed a large undulating surface with triangular cavities. The author

[1] 'Minéralogie de la France,' 1901, Tome iii, Fasc. 1, p. 100.

observes that—'It gives almost uninterrupted reflections between H_0 and ξ, which are most clear in the neighbourhood of H_1. These are without doubt due to natural corrosion.'

The following is a list, partly compiled from that given by Gonnard[1], of the faces hitherto observed between r and z in the zone $[rz]$ on quartz. The indices are here all given as for faces lying to the left of r or to the right of z.

Symbol.	Calc. angle $(hkl) : (100)$.	Miller.	Bravais.	Observer[2].
d_{10}	3° 1′	41.$\bar{1}$.2	1.13.$\bar{14}$.14	Websky.
γ_3	3 16	38.$\bar{1}$.2	1.12.$\bar{13}$.13	vom Rath.
d_9	4 16	29.$\bar{1}$.2	1.9.$\bar{10}$.10	Websky.
d_8	5 22	23.$\bar{1}$.2	1788	,,
d_7 / H	7 14	17.$\bar{1}$.2	1566	Websky. / Des Cloizeaux.
d_6 / H_0	8 11	15.$\bar{1}$.2	3.13.$\bar{16}$.16	Websky. / Gonnard.
d_5 / H_1	8 45	14.$\bar{1}$.2	1455	Websky. / Des Cloizeaux.
d_4	9 25	13.$\bar{1}$.2	3.11.$\bar{14}$.14	Websky.
d_3 / H_2	11 5	11.$\bar{1}$.2	1344	Websky. / Des Cloizeaux.
γ_{11}	12 9	10.$\bar{1}$.2	3.8.$\bar{11}$.11	vom Rath.
d_2	13 26	9$\bar{1}$2	3.7.$\bar{10}$.10	Websky.
ϕ_1	13 50	121.$\bar{14}$.28	14.31.$\bar{45}$.45	Barker.
H_4	14 21	42.$\bar{5}$.10	15.32.$\bar{47}$.47	Gonnard.
d_1 / γ	15 2	8$\bar{1}$2	1233	Websky. / Des Cloizeaux.
H_5	19 38	6$\bar{1}$2	3477	Gonnard.
H_6	22 9	21.$\bar{4}$.8	12.13.$\bar{25}$.25	,,
ξ	23 8	5$\bar{1}$2	1122	Des Cloizeaux.
ξ_1	26 38	17.$\bar{4}$.8	4377	Termier.
ϕ_3	27 43	77.$\bar{19}$.38	19.13.$\bar{32}$.32	Barker.
γ_0	28 1	4$\bar{1}$2	3255	Termier.
ξ_2	29 14	19.$\bar{5}$.10	5388	Gonnard.
ξ_3	30 32	18.$\bar{5}$.10	15.8.$\bar{23}$.23	,,
γ_1	31 14	7$\bar{2}$4	2133	Des Cloizeaux.
γ_2	32 50	23.$\bar{7}$.14	7.3.$\bar{10}$.10	,,
ξ_4	33 30	16.$\bar{5}$.10	5277	Gonnard.
β	35 11	3$\bar{1}$2	3144	vom Rath.
β_1	36 29	20.$\bar{7}$.14	7299	Des Cloizeaux.
γ_4	40 6	5$\bar{2}$4	6177	Gonnard.
β_5	41 14	12.$\bar{5}$.10	15.2.$\bar{17}$.17	,,
β_6	43 38	11.$\bar{5}$.10	15.1.$\bar{16}$.16	,,
ϕ_4	44 46	19.$\bar{9}$.18	27.1.$\bar{28}$.28	Barker.
ϕ_5	45 28	35.$\bar{17}$.34	51.1.$\bar{52}$.52	,,

[1] Bull. Soc. franç. Min., 1902, vol. xxv, p. 62.

[2] Authorities cited in the table :—

M. Websky, Ann. Phys. Chem. (Poggendorff), 1856, vol. xcix, p. 296 ; and Neues Jahrb. Min., 1871, p. 908.

A. Des Cloizeaux, Ann. Chim. Phys., 1855, ser. 3, vol. xlv, p. 129; and 'Mém.

It appears from the statements of previous authors, and from my own observations, that of the above faces d_{10}, ϕ_1, H_4, H_5, H_6, ϕ_3, γ_0, ξ_2, ξ_4, β_5, β_6, ϕ_4, and ϕ_5 occur on the left of r, their indices being of the form $\{h\bar{l}k\}$, where $k = 2l$; while γ_3, $H(d_7)$, $H_0(d_6)$, $H_1(d_5)$, $H_2(d_3)$, ξ_1, β_1, and γ_4, lie on the right of r, their indices being of the form $\{hk\bar{l}\}$; finally, γ_{11}, d_2, $\gamma(d_1)$, γ_1, and β occur both on the right and left of r. It is impossible to determine the positions of the remaining forms.

Gonnard[1] identifies his face γ_0 (32$\bar{5}$5) with a face Γ_1 (32.$\bar{17}$.$\bar{15}$.62) found by Termier. It may be seen, however, that Γ_1 does not lie in the zone $[rz]$. The error probably arose from the similarity of angles. $[r\Gamma_1 = 28° 14', r\gamma_0 = 28° 20'$ (observed values)].

Again in fig. 2[2] of crystal *A* (quartz from Meylan) the faces ξ_2, H_5, β_6 appear to be wrongly lettered, since the order of the faces in the zone should from the indices be z, β_6, ξ_2, H_5.

In two cases Gonnard[3] describes as 'dextrogyre,' crystals showing *s*-faces with left-handed striations, and again on p. 112 he seems to invert the ordinary use of the terms right- and left-handed.

The relative position of the Millerian and Bravais axes used above, is that adopted by Professor Miers[4] and Professor Lewis[5], in which the lateral hexagonal axes xyz are perpendicular to the planes containing the vertical axis w and the rhombohedral axes XYZ respectively. The axes XYZ, xyz (seen from above) are arranged counter-clockwise—the order being $+x$, $-z$, X, $+y$, $-x$, Y, $+z$, $-y$, Z.

sur la crist. et la structure intérieure du quartz' (Mém. prés. à l'Acad. Paris, 1858, vol. xv).

G. vom Rath, Zeits. Kryst. Min., 1881, vol. v, p. 1; and 1885, vol. x, p. 156.

P. Termier, Bull. Soc. franç. Min., 1895, vol. xviii, p. 443.

F. Gonnard, Bull. Soc. franç. Min., 1899, vol. xxii, pp. 92, 94; and 1902, vol. xxv, pp. 56, 90.

[1] Bull. Soc. franç. Min., 1902, vol. xxv, p. 61.

[2] Bull. Soc. franç. Min., 1899, vol. xxii, p. 97.

[3] Ibid., p. 93, fig. 1, and p. 124, fig. 1.

[4] Mineralogy, 1902, p. 66.

[5] Crystallography, 1899, p. 454.

Sulpharsenites of lead from the Binnenthal. Part IV.—Seligmannite: with a supplementary note on Baumhauerite.

By R. H. Solly, M.A.

[Read November 18, 1902.]

Seligmannite.

PROFESSOR Baumhauer[1], in January, 1901, described five very small crystals of a new mineral, to which he gave the name seligmannite. They were associated with rathite and binnite in dolomite, and came from the Lengenbach quarries in the Binnenthal, Switzerland. In June, 1902, he[2] described another crystal, the angles of which agreed fairly well with those of the crystals he had previously measured. In habit and twinning, these orthorhombic crystals so closely resembled bournonite that he ventured to assign to the new mineral the chemical formula $Cu_2S.2PbS.As_2S_3$, but from paucity of material he was unable to make a chemical analysis.

In September, 1902, I received from Binn four specimens of dufrenoysite, on which were deposited a number of minute but very brilliant crystals. The largest crystal measured $2 \times 1\frac{3}{4} \times \frac{3}{4}$ mm., and the others varied from $\frac{1}{4}$ to 1 mm. Twelve small crystals were removed for measurement, and proved to be this new mineral, seligmannite. A qualitative analysis of four of these crystals performed, under the kind direction of Mr. H. J. H. Fenton, in the University Chemical Laboratory at Cambridge, proved the presence of copper, lead, sulphur, and arsenic. It is, therefore, highly probable that when more crystals are available for quantitative analysis, the chemical composition of this mineral will be found to be the one suggested by Baumhauer on the grounds of its crystallographic isomorphism with bournonite.

The elements deduced from the crystallographic determination of these twelve crystals differ slightly from those obtained by Baumhauer:—

$$a : b : c = 0{\cdot}92804 : 1 : 0{\cdot}87568 \text{ (Baumhauer)},$$
$$a : b : c = 0{\cdot}92332 : 1 : 0{\cdot}87338 \text{ (Solly)}.$$

[1] Baumhauer, Sitz.-ber. Akad. Wiss. Berlin, 1901, p. 110; abstract, this vol., p. 205.

[2] Ibid., 1902, p. 611.

The latter ratios were calculated from (011) : (001) = 41° 8′, (100) : (101) = 46° 35½′, and (010) : (120) = 28° 26′. These angles were measured on the best crystals, and the reflections were very sharp.

The crystals are all twinned about (110) and some about ($\bar{1}10$).

	Calculated.	Measured.	
	Solly.	Solly.	Baumhauer.
$110 : \bar{1}\bar{1}0$	9° 8′	9° 8′	8° 41′, 8° 54′
$111 : \bar{1}\bar{1}\bar{1}$	7 13	7 13	6° 48½′.

The (100), (010), and (001) planes are usually well developed. The plane (110) is always large and striated parallel to its intersection with the planes (100) and (111); besides these striations there are sometimes fine striae parallel to the zone-axis [$1\bar{1}\bar{1}$], but not parallel to the zone-axis [$\bar{1}1\bar{1}$] as would be required by the symmetry of the crystal. The planes (111), (101), (011), and (112) are often well developed.

The colour of the mineral is lead-grey; the lustre is metallic and brilliant; the streak, chocolate-colour. The mineral is opaque. No cleavage was observed. Fracture, conchoidal. Hardness, 3. Specific gravity, not determined, owing to lack of material.

List of Forms observed on Seligmannite.

Symbol.	Indices.	Observer.	Symbol.	Indices.	Observer.	Symbol.	Indices.	Observer.
a	100	Baumh.	z	021	Baumh.	C	311	Baumh.
b	010	,,	n	011	,,	v	211	,,
c	001	,,	$\frac{2}{5}\kappa$	025	Solly	D	322	Solly
i	130	,,	κ	013	Baumh.	u	112	Baumh.
f	120	,,	o	101	,,	ϕ	113	Solly
m	110	,,	x	102	Solly	$\frac{3}{2}p$	229	,,
e	210	,,	ϵ	103	,,	$3p$	331	,,
η	310	Solly	t	104	,,	$4p$	441	,,
A	410	Baumh.	Δ	105	,,	ι	213	Baumh.
q	510	,,	ρ	121	Baumh.	W	431	,,
B	071	,,	y	111	,,	O	1.10.2	,,
Σ	031	,,	s	212	Solly			

The total number of forms is thirty-five, of these twenty-three were recorded by Baumhauer. The twelve new forms are all well developed. I have not observed Baumhauer's (021), (031), (071), and (1.10.2).

Below are given the calculated angles and the best measurements from the twelve crystals; also the smallest and greatest angles obtained by Baumhauer between similar planes.

Calculated and measured Angles of Seligmannite.

	Calculated.	Measured.			
	Solly.	Solly.		Baumhauer.	
Zone [100,010].					
100 : 510	10°27½′	10°28′		9°57½′	
: 410	13 0	12 59	13° 0′	13 2½	
: 310	17 6½	17 6	17 8		
: 210	24 47	24 47	24 48	24 50½	24° 54′
: 110	42 43	42 43	42 44	42 36	42 47
: 120	61 34	61 34		61 37½	61 50½
: 130	70 9	70 10		70 34	
: 010	90 0	90 0		89 48½	90 2
Zone [100,001].					
100 : 101	46 35½	46 35½		46 35½	46 44
: 102	64 41½	64 40	64 41		
: 103	72 30	72 28			
: 104	76 41½	76 41			
: 105	79 17	79 15			
Zone [001,010].					
001 : 013	16 14	16 14		16 14¼	
: 025	19 15½	19 15½			
: 011	41 8	41 8		41 7½	41 20
: 021	60 16			60 21	
: 031	69 6½			67 44½	69 41
: 071	80 42½			80 36½	80 37½
: 010	90 0	90 0			
Zone [001,110].					
001 : 229	15 58	15 58			
: 113	23 13½	23 15			
: 112	32 46	32 46		32 44	32 51½
: 111	52 9½	52 9		52 8	52 23
: 331	75 29	75 30			
: 441	79 0½	79 0			
: 110	90 0	90 0		90 0	
Zone [001,210].					
001 : 213	34 46½	34 46			
: 212	46 10	46 10			
: 211	64 21½	64 21		64 24½	64 27½
: 210	90 0	90 0			

	Calculated. Solly.	Measured. Solly.	Baumhauer.	
Zone [100,011].				
100 : 311	25° 4½′	25° 0′	25° 9½′	
: 211	35 3½	35 4	34 54	35° 5½′
: 322	43 6	43 8		
: 111	54 32	54 32	54 35½	54 36
: 011	90 0	90 0		
Zone [010,101].				
010 : 121	38 14½	38 14½	37 59	38 16¾
: 111	57 36½	57 36½	57 33½	57 35½
: 212	72 24	72 24		
: 101	90 0	90 0		
Zone [110,101].				
110 : 431	14 37	14 37	14 20	
: 211	30 56½	30 56½	30 50	30 54½
: 101	59 41	59 41	59 42½	59 48½
: 2$\bar{1}$3	77 24	77 23		
: 1$\bar{1}$2	87 32	87 32		
: 0$\bar{1}$1	116 30	116 30	116 29½	116 37½
: $\bar{1}\bar{2}$1	147 42	147 42	147 50	
: $\bar{1}\bar{1}$0	180 0	180 0		
001 : 121	62 49	62 50	63 23½	
001 : 431	77 44	77 44	77 6½	
010 : 1.10.2	14 13½		14 13¼	
101 : 0$\bar{1}$1	56 49	56 49		

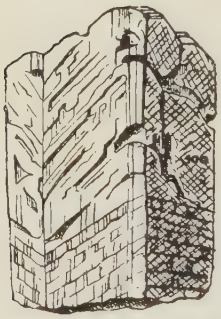
Baumhauerite [1].

In September, 1902, some fine specimens of this recently discovered mineral were found in the Lengenbach quarries in the Binnenthal. The largest crystal measured 25 × 20 × 10 mm.; the colour is steel-grey with very brilliant lustre; and the habit is slightly different from that of the crystals previously described. The difference lies in their polysynthetic growth: the crystals are completely penetrated by numerous, very thin twin-lamellae, closely resembling those parallel to (074) of rathite [2]; further, there is twinning with (100) as twin-plane and face of union.

[1] The following note, which has already appeared in Zeits. Kryst. Min., 1903, vol. xxxvii, pp. 329-331, pl. V, fig. 5, is supplementary to Part III ('Baumhauerite, a new mineral.' This vol., 1902, pp. 151-160) of this series of papers on the sulpharsenites of lead from the Binnenthal.

[2] This vol., p. 80.

The accompanying figure is an exact representation of such a polysynthetic group, showing the twinning on (100) and the twin-lamellae. The cohesion existing between the individual crystals is so slight that the warmth of the hand will cause them to fly apart, and the fresh surfaces which are formed, instead of consisting of cleavage-planes or uneven surfaces, are composed of a number of very brilliant pyramid-faces.



Polysynthetic crystal of Baumhauerite.

In rathite the plane parallel to the twin-lamellae lies in a zone containing two of the axial planes, whereas in baumhauerite it is inclined to such a zone. It was impossible on my Fuess goniometer to do more than determine that the plane did not lie in the zone [100, 010], but Mr. G. F. Herbert Smith kindly measured some of the crystals on the British Museum three-circle goniometer, and found that the plane would have indices approximating to $(76\bar{1})$.

The following is a list of the twenty-five new forms which were observed on six crystals, and have to be added to the ninety-five already recorded. The forms (706), $(50\bar{3})$, $(80\bar{5})$, $(30\bar{8})$, and $(10\bar{3})$, previously observed only by Baumhauer, were also present on these crystals.

$-25\,h\,(25.0.1)$	$-\frac{7}{2}\,h\,(702)$	$+\frac{13}{4}\,h\,(13.0.\bar{4})$	$+\frac{5}{9}\,g\,(50\bar{9})$
$-19\,h\,(19.0.1)$	$-3\,h\,(301)$	$+\frac{11}{4}\,h\,(11.0.\bar{4})$	$+\frac{1}{6}\,g\,(10\bar{6})$
$-\frac{19}{2}\,h\,(19.0.2)$	$+\frac{15}{2}\,h\,(15.0.\bar{2})$	$+\frac{9}{4}\,h\,(90\bar{4})$	$+\frac{1}{7}\,g\,(10\bar{7})$
$-9\,h\,(901)$	$+7\,h\,(70\bar{1})$	$+\frac{11}{6}\,h\,(11.0.\bar{6})$	$+\frac{1}{12}\,g\,(1.0.\bar{12})$
$-\frac{17}{2}\,h\,(17.0.2)$	$+6\,h\,(60\bar{1})$	$+\frac{4}{3}\,h\,(40\bar{3})$	
$-\frac{15}{2}\,h\,(15.0.2)$	$+\frac{9}{2}\,h\,(90\bar{2})$	$+\frac{5}{4}\,h\,(50\bar{4})$	
$-4\,h\,(401)$	$+\frac{7}{2}\,h\,(70\bar{2})$	$+\frac{5}{6}\,g\,(50\bar{6})$	

The table below gives the calculated angles and the best measurements obtained from the six crystals which were measured.

	Calculated.	Measured.		
Zone [100,001].				
100 : 25.0.1	3°15½′	3°14′	3°12′	3°16′
: 19.0.1	4 16	4 20	4 12	4 18
: 19.0.2	8 14	8 15	8 14	8 16
: 901	8 52	8 54	8 50	8 53
: 17.0.2	9 22	9 23	9 21	9 22
: 15.0.2	10 34	10 33	10 32	10 33
: 401	18 54	18 56	18 54	18 55

	Calculated.	Measured.		
: 702	21°15½′	21°14′	21°14′	21°15′
: 301	24 14	24 12	24 12	24 15
100 : 15.0.$\bar{2}$	11 5	11 4	11 4	11 5
: 70$\bar{1}$	11 52½	11 52	11 53	11 52
: 60$\bar{1}$	13 50	13 50	13 49	13 50
: 90$\bar{2}$	18 21½	18 22	18 21	18 22
: 70$\bar{2}$	23 22	23 24	23 22	23 24
: 13.0.$\bar{4}$	25 2½	25 1	25 2	25 3
: 11.0.$\bar{4}$	29 10	29 10	29 10	29 9
: 90$\bar{4}$	34 44	34 45	34 44	34 45
: 11.0.$\bar{6}$	40 58½	40 58½	40 59	40 58½
: 40$\bar{3}$	51 15	51 15		
: 50$\bar{4}$	53 20	53 20	53 21	
: 50$\bar{6}$	65 35½	65 30	65 37	
: 50$\bar{9}$	75 25½	75 30	75 24	
: 10$\bar{6}$	90 40	90 40	90 40	90 39
: 107	91 37	91 35	91 37	91 36
: 1.0.$\bar{12}$	93 59	93 59		

Errata.

The following baumhauerite forms (this vol., pp. 153, 156, 159) require correction:—

For + $\frac{2}{13}g$ 2.0.$\bar{13}$ read + $\frac{2}{11}g$ 2.0.$\bar{11}$
„ + $\frac{1}{9}g$ 10$\bar{9}$ „ + $\frac{1}{8}g$ 10$\bar{8}$
„ + $\frac{1}{12}g$ 1.0.$\bar{12}$ „ + $\frac{1}{20}g$ 1.0.$\bar{20}$

Page 156. For 100 : 1.0.$\bar{12}$ = 95°12½′ read 100 : 1.0.$\bar{20}$ = 95°18½′ (calculated).
Fig. 1 (p. 152). For $\bar{1}$00 (at top of figure) read $\bar{1}$08.

On the Diathermancy of Antimonite.

By A. Hutchinson, M.A., Ph.D.

Demonstrator of Mineralogy in the University of Cambridge.

[Read March 24, 1903.]

A DETERMINATION of the constants of elliptic polarization of light reflected from a fresh cleavage surface of antimonite enabled Professor P. Drude [1] to calculate two of the indices of refraction of this substance as 5·17 and 4·49 respectively. Instead, however, of the symmetry-axes of the crystal, regarded as belonging to the orthorhombic system, coinciding with the principal vibration directions in the plane (010), he found that the latter were inclined to the former lines at angles which varied in different observations between 2·6° and 15·4°. These observations, which indicate that the symmetry of antimonite is of the oblique or anorthic type [2], stand in opposition to those of Professor O. Mügge [3], who found that exceedingly thin flakes of antimonite placed between crossed nicols in direct sunlight transmitted sufficient light of a deep red colour to enable him to determine the extinction as straight.

As, however, the morphological and physical characters of antimonite taken as a whole, are those of an orthorhombic crystal, it seemed desirable to find, if possible, some new method of testing the transmission of radiant energy by crystalline substances, such as antimonite, which are opaque to light. A clue to such a method was found in an observation of Schultz-Sellack [4], who showed, some thirty years ago, that zinc-blende was very diathermanous, and that artificial sulphide of arsenic possessed the same property though to a less extent. It seemed probable therefore that antimonite might also be sufficiently diathermanous to enable its behaviour towards radiations of long wave-length to be determined, and to thus afford data on which conclusions as to its crystal-system might be based. On trial this proved to be the case, and the behaviour of a thin cleavage flake of antimonite was found to be consistent with orthorhombic symmetry [5].

[1] Ann. Phys. Chem. (Wiedemann), 1888, vol. xxxiv, p. 489.

[2] Loc. cit., p. 527.

[3] Neues Jahrb. Min., 1898, vol. i, p. 12.

[4] Ann. Phys. Chem. (Poggendorff), 1870, vol. cxxxix, p. 182.

[5] Since this paper was written E. C. Müller has published an elaborate investigation entitled 'Optische Studien am Antimonglanz,' Neues Jahrb. Min., 1903, Beil.-Bd.

Apparatus and mode of experimenting.—The source of radiation was an ordinary lime-light fed with coal-gas and oxygen. The radiation from the incandescent lime was focused on the thermo-couple of a Boys' radiomicrometer, placed at a distance of about 75 cm. from the lime, by means of a quartz lens 5 cm. in diameter and 9 cm. focal length. A microscope, provided with a rotating stage graduated in degrees, was fixed between the lens and the radiomicrometer. The tube of the microscope was placed horizontally and all the lenses removed. To adjust the flake of antimonite on the rotating stage, the flake was either placed between two pieces of cardboard in which holes had been made or else fastened by a little wax to a very thin piece of glass (a cover-slip). The latter proved to be the more convenient arrangement, as the amount of radiation stopped by the glass was found to be inappreciable. Before reaching the antimonite the heat-rays were polarized by passing through an ordinary nicol prism fitted in the substage of the microscope-stand. This prism was 5 cm. long and measured 2·5 cm. along the short diagonal of the end face. On the other side of the antimonite plate an analyser was fitted in the tube of the microscope: this was a square-ended prism measuring $4{\cdot}5 \times 1{\cdot}7 \times 1{\cdot}7$ cm.

The radiomicrometer, consisting of an antimony-bismuth couple suspended by a quartz fibre between the poles of a permanent magnet, was of the pattern described by Mr. Boys[1], and belongs to the Cavendish Laboratory. It is a very sensitive and trustworthy instrument, and I am greatly indebted to Professor J. J. Thomson for the loan of it[2]. The position of the image reflected from the mirror of the radiomicrometer was determined by means of a centimetre scale bent into a circular arc of 113 cm. radius, having for centre the position of the mirror. The readings were taken to 1 mm. and the maximum deviation observed, amounting to 18 cm., corresponds to a rotation of the radiomicrometer mirror through approximately 5°. Great care was taken to protect the radiomicrometer from stray radiations by means of suitable screens, and from vibration by mounting it on india-rubber blocks supported on a solid stone shelf built into the wall of the room in which the experiments were made, but in spite of these precautions the vibrations caused

xvii, pp. 187-251. This research, conducted by methods similar to those employed by Drude (loc. cit.), has led Müller to conclude that Drude was mistaken in attributing oblique or anorthic symmetry to antimonite, as all his own results are consistent with the view that antimonite crystallizes in the orthorhombic system.

[1] Phil. Trans. Roy. Soc., 1889, vol. clxxx, p. 159.

[2] I desire here to record my thanks to my friend Mr. Skinner, of the Cavendish Laboratory, for much kind help in setting up apparatus.

by traffic in the neighbouring street were a source of much inconvenience.

The arrangements, then, were essentially the same as those employed for examining crystal sections in parallel plane polarized light, the thermo-couple of the radiomicrometer being substituted for the observer's eye. It was found on trial that when the nicols were crossed no measurable radiation reached the radiomicrometer: on the other hand, when their principal planes were parallel the effect produced was so great that the spot of light instantly travelled off the scale.

A thin cleavage flake was next prepared from a crystal of Japanese antimonite. It proved on measurement to be 0·29 mm. thick. In some experiments the whole area of the plate (35 to 40 sq. mm.) was employed, in others it was limited to 20 sq. mm. by holes cut in the cardboard mount. The direction of the symmetry-axes lying in the cleavage face (010) can be easily identified either by the bounding edges made by planes belonging to the zone [100,010], or by the striae due to the presence of slip-planes lying in the zone [010,001]. By means of these striae the plate was brought into a definite position in the following way:—the tube of the microscope was fitted with a low power objective and with an eyepiece provided with cross-wires. The nicols were crossed and a quartz crystal adjusted on the stage so as to be in the position of extinction when the circle reading was 0°. The cross-wires were placed respectively parallel and perpendicular to the axis of the quartz crystal, which was then removed and replaced by the antimonite; this was in its turn adjusted till one of the cross-wires coincided with the striae. The eyepiece and objective were then removed, leaving the nicols untouched.

Now, since the striae on (010) are parallel to the brachy-axis of the crystal, and since these striae have been set to coincide with one or other of the vibration directions of the nicols, it follows that if the crystal is really orthorhombic the flake is in the position of extinction, and that on allowing the radiation to fall on it no indication should be given by the radiomicrometer, while on turning the flake in its own plane heat should be transmitted, the amount reaching a maximum for rotations of 45° from the zero position. On trial these predictions were found to be completely verified and the orthorhombic symmetry of antimonite confirmed.

Results.—The results obtained may be illustrated by the following figures:—

Circle:	0°	10°	20°	30°	40°	45°	50°	60°	70°	80°	90°.
Scale:	0	2	$7\frac{1}{2}$	$13\frac{1}{2}$	$17\frac{1}{2}$	18	$17\frac{1}{2}$	13	$6\frac{1}{2}$	$1\frac{1}{2}$	0.

Under the heading 'circle' are given the readings of the graduated stage to which the antimonite was attached; the readings being 0° or 90° when the vibration directions in the plate, as determined by the striae, coincided with the vibration directions of the nicols. Under 'scale' are given the corresponding deflections in cm. of the spot of light on the scale of the radiomicrometer, and these may be taken as directly proportional to the amount of heat transmitted.

These observations, while supporting those of Professor Mügge, stand in opposition to those of Professor Drude, as the results obtained by the latter require that the plate should transmit radiation when set in the position above described, but should cease to do so after being turned through an angle varying from 2° to 15°.

An attempt was made to determine the intensity of the radiation transmitted at every 10° during a complete rotation of the plate in its own plane. It was not, however, found possible to keep the source of radiation sufficiently constant during the rather considerable time requisite for taking the necessary readings. The results may be most conveniently exhibited by plotting them on squared paper. When this is done and a curve drawn, it is noticed that in the neighbourhood of the maxima and minima of heat transmission an alteration of 5° in the azimuth of the crystal plate makes hardly any difference in the reading of the radiomicrometer, and therefore it may be objected that the sensitiveness of the method is not sufficient to fix within 5° or even 10° the position of the principal vibration directions in the plate. This difficulty can be overcome by comparing pairs of observations at the more sensitive parts of the curve; as, for instance, at 15° and 75° or at 30° and 60°. If the vibration directions of the plate and of the nicols coincide when the reading of the circle is 0°, then the radiomicrometer readings at 15° and 30° must be equal to the readings at 75° and 60° respectively. The following numbers may be quoted in illustration of this point:—

Circle:	15°	30°	60°	75°	105°	120°	135°	150°	165°	195°.
Scale:	$2\frac{1}{2}$	$6\frac{3}{4}$	$6\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$6\frac{3}{4}$	$8\frac{3}{4}$	$6\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{2}$

It will be seen that the corresponding readings on each side of the maxima found at 45° and 135°, or taken at equal inclinations to the minima which occur at 0°, 90°, and 180°, exhibit a satisfactory degree of concordance. Had the readings not accorded as shown in the above observations, the directions of the striae would not be those of symmetry-axes, and the true direction of extinction would be in some other posi-

tion, and could be deduced from the mean of two positions of equal transmission, or by the method described in the next paragraph.

The intensity, I, of the illumination transmitted by a thin crystal plate placed between crossed nicols is given by the expression

$$I = a^2 \sin^2 2\theta \sin^2 \delta/2,$$

where θ is the angle through which the plate has been turned from the position of extinction. This expression must hold for radiant heat as well as for light, and the scale readings of the radiomicrometer are proportional to the heat transmitted. Suppose, then, that the plate is set in a position making an angle θ with the position of extinction and let the scale reading of the radiomicrometer be x divisions. Next let the plate be turned into the position ϕ through a known angle $\phi - \theta = \psi$, and let the corresponding reading of the radiomicrometer be y. We know then x, y, and the angle ψ, and require to calculate θ or ϕ.

We have $a^2 \sin^2 2\phi \sin^2 \delta/2 = yk$,

and $a^2 \sin^2 2\theta \sin^2 \delta/2 = xk$;

hence $\sin 2\phi / \sin 2\theta = \sqrt{y/x}$.

But $\phi = \theta + \psi$,

and $$\frac{\sin(2\theta + 2\psi)}{\sin 2\theta} = \frac{\sin 2\theta \cos 2\psi + \cos 2\theta \sin 2\psi}{\sin 2\theta},$$

whence $$\cos 2\psi + \cot 2\theta \sin 2\psi = \sqrt{y/x}.$$

We may make ψ any convenient value we please, such as 15°, 22½°, or 30°.

If $\psi = 15°$ we have

$$\cos 30° + \cot 2\theta \sin 30° = \sqrt{y/x} \text{ or } \cot 2\theta = 2\sqrt{y/x} - \sqrt{3}.$$

If $\psi = 22\frac{1}{2}°$ we have

$$\cos 45° + \cot 2\theta \sin 45° = \sqrt{y/x} \text{ or } \cot 2\theta = \sqrt{2y/x} - 1.$$

If $\psi = 30°$ we have

$$\cos 60° + \cot 2\theta \sin 60° = \sqrt{y/x} \text{ or } \cot 2\theta = 2\sqrt{y/3x} - 1/\sqrt{3}.$$

Thus from two observations the position of extinction may be found. This method has the great advantage that the observations are made at a sensitive part of the curve, and can be so quickly taken that the source of radiation has not time to alter in intensity.

The following example will illustrate the application of this method. The radiomicrometer reading corresponding to a certain position of the crystal plate was 2 scale divisions; on turning the plate through 30° the corresponding reading was 17½ divisions. Substituting, therefore, in the expression $\cot 2\theta = 2\sqrt{y/3x} - 1/\sqrt{3}$ we get

$$\cot 2\theta = 2\sqrt{35/12} - 0{\cdot}5773 = 2{\cdot}839, \text{ whence } \theta = 9° 42'.$$

In order, therefore, to put the plate into the position in which its vibration directions coincide with those of the nicols, it must be turned through 9° 42′ in the opposite sense to its former rotation. After making this adjustment it was found that the directions of vibration in the plate coincided with the directions of the striae.

The experiments described above are to be regarded as of a preliminary character only and leave many interesting points unsettled. Thus the wave-lengths of the radiations transmitted by the antimonite have still to be determined, and the refractive indices of the crystal for these radiations measured. The variations in the absorption for rays vibrating in different directions have also to be studied. It will, moreover, be of interest to discover how far the method is applicable to other substances opaque to light. I hope shortly to be able to extend the investigation in these directions, and to improve materially the delicacy of the method by substituting for lime-light either sunlight or the electric arc.

1. *Anatase in the Trias of the Midlands of England.* 2. *A peculiar occurrence of Magnetite in the Upper Bunter Sands.*

By John B. Scrivenor, M.A., F.G.S.

Of H.M. Geological Survey.

[Read March 24, 1903.]

1. *Anatase in the Trias of the Midlands of England.*

THE mode of occurrence and origin of the various forms of titanium dioxide as rock constituents have received attention at the hands of many petrologists, both on the continent and in our own country. Among the works of the former dealing with this subject, Thürach's exhaustive treatise[1] on microscopic rock-forming rutile, anatase, and brookite, is undoubtedly the most important: in England, Mr. Maynard Hutchings has described in great detail the occurrence of rutile and anatase both as constituents of clays and slates[2], and as a product of contact metamorphism in the Lower Coniston Flags[3] in the neighbourhood of the Shap granite; Mr. J. J. H. Teall has also described rutile needles and anatase crystals from clays of various ages[4], and anatase from the Cleveland iron-ore[5]; Mr. Allan Dick[6] has mentioned the occurrence of rutile in the Bagshot Sands; and Mr. H. H. Thomas[7] has lately described these minerals from the Budleigh Salterton Pebble-bed of Devonshire.

I have been for some time engaged in examining the mineral constitution of the Triassic sandstones of the Midlands, and have found that of the heavier minerals, that is, those exceeding a specific gravity of 2·8, anatase, both by reason of its abundance and its mode of occurrence, is the most interesting, so much so that although Thürach has already

[1] 'Über das Vorkommen mikroskopischer Zirkone und Titan-Mineralien in den Gesteinen.' Verh. physik.-medic. Ges. Würzburg, 1884, N. F. vol. xviii, No. 10, pp. 1–82.

[2] Geol. Mag., 1890, p. 264.

[3] Quart. Journ. Geol. Soc., 1891, vol. xlvii, p. 318; Geol. Mag., 1891, pp. 459, 528.

[4] Min. Mag., 1887, vol. vii, p. 201.

[5] 'British Petrography,' 1888, pl. 44, fig. 6.

[6] Nature, 1887, vol. xxvi, p. 91.

[7] Quart. Journ. Geol. Soc., 1902, vol. lviii, p. 620.

called attention to the widespread distribution of this mineral, and has expressed his opinion as to its origin in various rocks, it has been thought worthy of a brief description.

Of a large number of sandstones, few failed to yield more or less anatase; and even where it was not found after a single separation there is no reason to doubt that, judging by the similarity of the associated minerals, a more protracted search would have resulted in success. Although nearly always present, it was found, however, that the ratio of the anatase to the other minerals in the heavy residues was always greater in specimens from the Keuper than in those from the Bunter. The following have been selected as affording the best material for the study of this mineral:—Keuper sandstone from Sutton Coldfield, Storeton in Cheshire, and Weston, also in Cheshire; sandstone from the Bunter Pebble-bed at Dale Abbey, near Derby, and Bunter sandstone from Kingswinford, near Stourbridge.

The anatase crystals vary considerably in size. The smallest that have been measured are 0·025 mm. in greatest diameter; the majority average 0·06 mm.; while a few, especially those with the octahedral faces well developed, reach 0·17 mm. As far as can be ascertained the individuals are composed entirely of the forms {111} and {001}, the extent of development of the latter determining the pyramidal or tabular habit of the crystal. Perfect pyramids, however, with the basal plane completely suppressed, have not been seen. The crystals are generally colourless; but some exceptions have been seen in the specimens from Dale Abbey, where a violet-brown and a yellow crystal were found. Similarly, the crystals are generally perfectly clear, a feature which is partially masked in those with a pronounced pyramidal habit by the strong total reflection; but some, especially among the larger tabular crystals, are encrusted with a granular substance which is white by reflected light. In convergent light, all the crystals were found to be abnormally biaxial, the uniaxial cross opening slightly into hyperbolae on rotation.

Detached crystals occur in these sandstones, but it was noticed that these are very rarely perfect, some flaw being nearly always evident. On the other hand, clusters of minute crystals are frequently met with, and also larger crystals, with a perfectly sharp outline, projecting from the surface of grains of a white substance, sometimes tinged with yellow, red, or brown, which there is every reason to suppose is leucoxene. In support of this view, which it is impossible to prove by chemical methods in the presence of a known titaniferous mineral, it may be mentioned that the nucleus of these white masses has often been

found to be an opaque black mineral, similar to the cores of ilmenite in masses of leucoxene in igneous rocks. The cleavages parallel to (111) and (001) are rarely evident.

If, like the minerals with which it occurs, namely, zircon, rutile, tourmaline, staurolite, &c., the anatase is of detrital origin, there are two difficulties to be accounted for. First, how is it that the cleavages, which are described as perfect, are not better developed? and again, how is it that the crystals, which are softer than rutile, zircon, or tourmaline, present so sharp an outline, while the last-named minerals are, with few exceptions, distinctly worn? For the sake of comparison, a specimen of anatase from the altered Lower Coniston Flags was examined, with the result that there appeared to be no possibility of the crystals in the sandstones having been derived from such a source, the disparity of size (those in the altered flags being very minute) and the prevalence of the pyramidal habit being fatal objections; nor is there known to be any source within reasonable distance where larger crystals could be derived, such as those mentioned by Thürach as occurring in the granite of Striegau.

That these anatase crystals in the sandstone had been formed after the deposition of the sand, suggested itself early in these investigations; but when undoubted anatase crystals were found completely enclosed in quartz this view had for the time to be abandoned, and for some time no way out of the difficulty was forthcoming. However, the solution presented itself in the Keuper sandstone from Weston, where a detached crystal of anatase was found with a beautifully doubly-terminated quartz crystal growing on it, measuring not more than 0·07 mm. That this delicate quartz crystal had been formed after the deposition of the sand cannot be doubted: if it had been transported by wind or by water, it could not have failed to have become detached from the anatase. Therefore, although one could believe that some, at least, of the anatase came from a distance, if a reasonable source could be pointed out, a sufficient explanation for these quartz-enveloped clusters is that they have become surrounded by a deposition of secondary silica.

When one considers the purely secondary nature of rock-making anatase, that it never is known to occur in fresh igneous rocks, and how abundant and bewildering are the changes experienced by the titaniferous minerals among themselves, in addition to the above considerations of perfection of outline, rarity of cleavage traces, and the absence of any known available source if of detrital origin, the conclusion cannot be resisted that these anatase crystals have been formed, after the deposition

of the sandstone, from leucoxene, which in turn has been derived from other titaniferous minerals, chiefly ilmenite.

There is another possible source of the anatase. Both my friend Mr. Thomas and myself, while working on the Triassic sandstones, were struck by the great scarcity of sphene, which from its widespread occurrence in igneous rocks, might be expected to be abundant. That this may be accounted for by supposing that some of the anatase has been derived from this mineral, either with or without the formation of leucoxene as an intermediary stage, is very probable, seeing that Diller has described anatase after sphene in amphibole-granite and in 'Schalstein[1].'

In these Triassic sandstones, then, we have, first, leucoxene after ilmenite, then anatase after leucoxene, and lastly secondary quartz deposited on the anatase. Why the leucoxene should afford anatase instead of sphene, an alteration common in other rocks, cannot be explained, seeing that the conditions under which the change took place cannot have been far removed from those of ordinary weathering. Were we dealing with contact metamorphism the problem would be comparatively simple; indeed in the case of the re-crystallization of rutile as anatase, described by Mr. Maynard Hutchings[2], and as brookite, described by Beck in the Silurian clays of Saxony[3], the experiments of Hautefeuille can be profitably appealed to; but in this case, where the conditions cannot have been such as Hautefeuille demanded for the artificial formation of rutile, or even those under which the experiments of Daubrée and Deville were conducted, we must accept the phenomenon as an instance of the unaccountable vagaries of titaniferous minerals, whose only conception of order seems to be a tendency towards the form rutile.

In conclusion, I must record my indebtedness to those who have offered me their assistance, especially to Mr. Allan Dick, and to Mr. Maynard Hutchings, who has placed at my disposal his preparations described in the 'Quarterly Journal of the Geological Society' and in the 'Geological Magazine.'

2. *A peculiar occurrence of Magnetite in the Upper Bunter Sands.*

The specimen of Upper Bunter Sands, in which this magnetite occurs, was collected at Hinksford (Staffordshire), near Stourbridge. It is a white, very loosely coherent sand of medium grain; and contains,

[1] Neues Jahrb. Min., 1883, vol. i, pp. 187, 189.
[2] Geol. Mag., 1891, p. 459.
[3] Min. petr. Mitt. (Tschermak), 1893, vol. xiii, p. 290.

as was found by separating the constituents in mercury-potassium iodide, turbid orthoclase, microcline, fragments of the micro-crystalline ground-mass of acid lavas or intrusive rocks, quartz, staurolite, tourmaline, garnet, zircon, rutile, muscovite, a little haematite, and abundant magnetite.

The grains of magnetite are very minute, averaging 0·067 mm., but nevertheless they present, with very few exceptions, a perfect crystal outline, that of a simple cube, or, in a few rare cases, that of a regular octahedron. That the mineral is magnetite can be demonstrated both by its behaviour with reagents and by the possibility of separating it from the other grains by a weak magnet. By strong reflected light the dull black surface is in some cases seen to be traversed by a single set of striae parallel to the cubic edge; while on others a red colour can be discerned at the corners of the cubes, which suggests an admixture of a small amount of haematite.

There are two possible explanations of this occurrence. It may, for the sake of argument, be assumed that the grains of the rock were formerly cemented by chalybite, which by oxidization became converted into magnetite, having a form similar to that of the minute cubes described by Sjögren from the Mossgrufva, Nordmark[1]. Apart from the difference of the mode of occurrence, there is, however, an important distinction between the Mossgrufva crystals and those under discussion. The former have their cube faces crossed by a double set of striae at right angles to one another and parallel to the edges, whereas the Hinksford crystals only show one set, which instantly recalls the hemihedral striae of pyrites. This apparently hemihedral striation suggests the second, and I believe the more probable view, namely that the magnetite is pseudomorphous after pyrites, a replacement of which only one record[2], and that a doubtful one[3], can be found in the British Isles, that given in Hall's 'Mineralogist's Directory,' the locality being Tarbet in Argyllshire.

[1] Hj. Sjögren, 'Contributions to Swedish Mineralogy.' Bull. Geol. Inst. Univ. Upsala, 1895, vol. ii, p. 63.

[2] T. M. Hall, 'Mineralogist's Directory,' 1868, p. 132.

[3] H. A. Miers, Min. Mag., 1897, vol. xi, p. 277.

Bakerite (a new borosilicate of calcium) and Howlite from California.

By W. B. Giles, F.I.C.

[Read March 24, 1903.]

THE new mineral to be described occurs as veins and as nodules of considerable size in the mines of the Borax Consolidated Company, Limited, situated in the Mohave Desert, sixteen miles north-east of Daggett in San Bernardino County, California. The white, amorphous[1] masses resemble in appearance unglazed porcelain or fine white marble. Sometimes the mineral has a faint tinge of a sea-green colour. Its hardness is about $4\frac{1}{2}$, and specific gravity 2·73. Up to the present time no specimens showing any signs of crystallization have been noticed. In external appearance the mineral shows a striking resemblance to the pandermite of Sultan Tchair in Asia Minor, and it may be here noted that this amorphous variety of calcium borate occurs also in the Californian mines.

A fragment of the mineral when heated on platinum wire before the blowpipe imparts to the flame a greenish colour and yields a white, perfectly transparent bead. When free from the external coating or matrix of calcite, the mineral is readily soluble in warm dilute hydrochloric acid without effervescence, and on evaporating the solution the silica gelatinizes. Analyses of two specimens from different mines yielded the following results:—

	White.	Faint greenish.
B_2O_3	27·74 ...	26·85
CaO	34·88 ...	35·22
SiO_2	28·45 ...	28·05
H_2O	8·30 ...	8·66
Al_2O_3, Fe_2O_3 ...	0·63 ...	1·22
	100·00	100·00

[1] Specimens of 'bakerite' presented by Mr. Giles to the British Museum appear to be perfectly homogeneous, except in one piece, which is intermixed with a little calcite. The microscopical examination of several fragments crushed in oil and of thin section showed the material to have an extremely minute spherulitic structure and to be feebly birefringent. There was nothing suggestive of a mixture of minerals. On the other hand, the specific gravity of several small fragments from two specimens

The water was estimated by calcining with materials, such as monosodic borate, which prevent any slight simultaneous loss of boric acid: the boric acid by the Ebelmen-Rose-Gooch method (distillation with methyl alcohol), but somewhat modified to make it more practicable than the Gooch process.

These analytical results give the formula:—

$$8CaO \cdot 5B_2O_3 \cdot 6SiO_2 \cdot 6H_2O.$$

The name bakerite is proposed in honour of Mr. R. C. Baker, of Nutfield, Surrey, one of the managing directors of the Company, and by whom the mineral was discovered.

The several borosilicates of calcium hitherto known are:—

Danburite, $CaO \cdot B_2O_3 \cdot 2SiO_2$.
Datolite, $2CaO \cdot B_2O_3 \cdot 2SiO_2 \cdot H_2O$.
Howlite, $4CaO \cdot 5B_2O_3 \cdot 2SiO_2 \cdot 5H_2O$.

For purposes of comparison, the calculated percentage compositions of these, together with that of bakerite, are given below.

	Danburite.	Datolite.	Howlite.	Bakerite.
B_2O_3	28·4	21·8	44·6	27·7
CaO	22·8	35·0	28·6	35·4
SiO_2	48·8	37·6	15·3	28·4
H_2O	—	5·6	11·5	8·5

Howlite.

This mineral, previously recorded only from Nova Scotia, has been considered to be of rare occurrence. It occurs, however, in immense quantities in the Californian borax mines mentioned above, and has been used commercially in the manufacture of borax and boric acid. One large nodule, or rather boulder, noticed by the author when he visited the mines, weighed between two and three hundredweight, and was snow-white, and almost pure. The mineral is found in many forms, sometimes in large masses of fine small scaly crystals soft enough to be crushed in the hand, and sometimes massive in hard rock-like and amorphous masses, and also in intermediate forms. In these mines howlite frequently occurs associated with natroborocalcite or 'cotton-

(differing somewhat in compactness and hardness) varied between about 2·7 and 2·93 (as determined in methylene iodide with indicators of calcite and aragonite).—L. J. Spencer.

ball,' and with colemanite. In the exceedingly dry air of these desolate regions the soft crystalline mineral loses some of its water.

Many analyses made by the author on various specimens agree exactly with the composition and formula given above.

Analyses of Californian Howlite.

	Pure white mineral in soft scale-like crystals.	Hard rock-like white masses, not crystalline.
B_2O_3	44·38 ...	43·78
CaO	28·45 ...	28·44
SiO_2	15·50 ...	15·33
H_2O	11·58 ...	11·39
Na_2O, MgO ...	0·09 ...	1·06
	100·00	100·00

Notes on the Wollastonite rock-mass, and its associated minerals, of the Santa Fé Mine, State of Chiapas, Mexico.

By Henry F. Collins, A.R.S.M.

[Read June 9, 1903.]

THE geological features of the immediate neighbourhood of the Santa Fé Mine, which is situated about nine leagues nearly due east of the departmental town of Pichucalco, have been partially described by the author in a paper[1] recently read before the Institution of Mining and Metallurgy. The key to the position, from the point of view alike of mineralogical and of economic interest, is found in a dome-shaped mass of wollastonite in a nearly pure condition, the horizontal section of which, at the lowest level where it has been sufficiently explored to determine its shape, takes the form of an irregular ellipse about 400 yards long by 160 yards wide. With the exception of the ore-bodies, which are developed on the outskirts of this mass and close to the contacts with other rocks, the whole mass is of nearly uniform composition, consisting of the mineral wollastonite in a nearly pure condition and very coarsely crystallized. Towards the outskirts of the mass the pure wollastonite contains a small proportion of garnet (andradite), and passes, usually by insensible gradations, into the payable ore-bodies. These are irregular in form and distribution, and, while still consisting of wollastonite as the principal gangue mineral, contain also small proportions of garnet, quartz, calcite, semi-opal, and other non-metallic minerals; while the principal valuable metallic minerals, bornite and chalcopyrite, are accompanied by small quantities of galena, pyrites, fahlerz, enargite, &c.

Except near the edge of the mass, the massive wollastonite is not crystallized confusedly from a number of centres, but shows a parallel orientation over distances of many feet. The mineral has two well-developed cleavages approximately at right angles to each other, and the mass breaks readily into fissile rectangular blocks; the resulting structure resembles that of satin-spar, the parallel crystalline fibres often, however, reaching three or four feet in length. In colour the wollastonite is—except where stained by traces of iron and other minerals—

[1] 'Concentration and smelting, as applied to the treatment of low grade gold-copper ores at Santa Fé (Mexico).'

pure white and translucent; its lustre varies from vitreous to satiny; its hardness is 5, and its specific gravity (average of several determinations) is 2·88.

Origin of the Wollastonite mass. Although a mineral of somewhat wide distribution, wollastonite has hitherto never been known to form the sole constituent of an important rock-mass, but is generally found associated with garnet, epidote, idocrase, and other well-known products of metamorphic action upon impure limestones near their contacts with igneous rocks. In the paper referred to, however, the author adduces arguments to show that this particular mass of wollastonite is not a product of metamorphism *in situ*, but that it has been intruded in a perfectly plastic condition, and that the ore-bodies have been separated from it by magmatic segregation. The principal arguments in favour of such a supposition may be recapitulated as follows:—

1. The wollastonite is absolutely isolated from the limestone rocks of the district, the nearest outcrop of which is situated at a distance of one mile from the outskirts of the mass.

2. It is completely surrounded on all sides by granite, felsite, diabase, and other igneous rocks. The felsite and diabase are in close association with the wollastonite, and the granite surrounds them all at a short distance.

3. The mass is hump- or dome-shaped, its outer surface dipping away from the centre in all directions. The top of the dome only just reaches the present surface, and at the time of its intrusion probably fell short of reaching the then existing surface by several thousand feet. No very long lapse of time, geologically speaking, is required for the denudation of a few thousand feet of rock in a mountainous tropical region possessing an average rainfall of about 200 inches per annum.

4. At a depth of 200 feet below its highest point, mining operations have fairly well mapped out the extent and form of the mass, and have proved it to cover an area about 400 yards long by 160 yards wide, while at an horizon 100 feet deeper its unbroken character has been already proved over an area at least 200 yards long by 80 yards wide. Near the upper surface and outer edge of this mass the pure wollastonite is contaminated with other minerals, is much split up, and includes fragments of the surrounding rocks; it is near this outer contact that ore-bodies have been developed, and that evidences of fissuring and of secondary alteration are met with. Near its outer fringe, moreover, the wollastonite has been penetrated by trap dykes of an obviously later origin. Taking, however, only the central unaltered and undisturbed

core of the mass, which certainly contains over two million cubic yards of material above the deepest level at which it has been yet opened up, while it presents every indication of continuing unaltered down to unknown depths, it is noteworthy that in the thorough exploration of this very large mass of rock by a network of drivages in all directions, no variation in composition is anywhere observable between different parts of the mass nor in the relative proportions of lime and silica present, no vestige of a transition from limestone to wollastonite, and no indication of a variation in the crystalline structure, which is perfectly developed and uniform throughout.

It is admittedly a unique occurrence for so large a mass of eruptive rock to be composed of practically a single mineral species, but it seems difficult to conceive that so large a mass of limestone could be gradually metamorphosed by siliceous solutions or vapours in such a way as to produce a pure anhydrous silicate of lime of absolutely definite composition and of uniformly macro-crystalline structure throughout. In portions of the rock-mass which are traversed by master-joints the crystalline fibres usually run perpendicularly to these joints, and are often strictly parallel to each other over a width of as much as fifty feet, and absolutely continuous for four to six feet from joint to joint. After long and careful study of the conditions on the spot the author is convinced that these and all the other observed facts can only be explained on the supposition of the eruptive origin of the wollastonite mass.

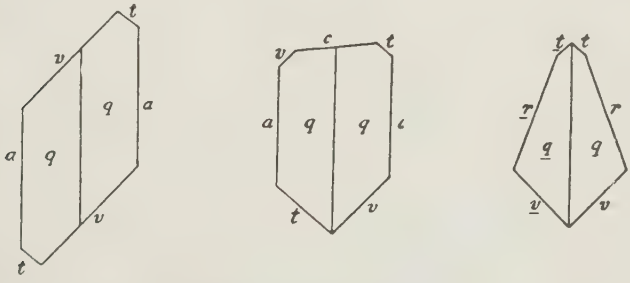
Crystals of Wollastonite. In cavities and open spaces near the outer edge of the wollastonite intrusion, stout tabular and prismatic crystals of wollastonite are found, varying from half an inch up to nearly a foot long, and the largest of these are almost invariably converted partially or entirely into quartz or semi-opal. The smaller crystals are always found in small cavities, which were almost completely sealed against the passage of solutions, and these have generally remained almost or quite unaltered; but the largest crystals are all found in much larger cavities, which have evidently at a later date been water channels, and most of these are almost entirely converted into silica, sometimes crypto-crystalline, sometimes amorphous. The largest and finest crystal found has been placed in the British Museum; it measures $10\frac{1}{4}$ inches long by $5\frac{1}{2}$ inches wide. Specimens of the unaltered wollastonite crystals, which are sometimes pink, though generally white, vary from $\frac{1}{2}$ inch long by $\frac{3}{8}$ in. wide, up to $2\frac{1}{4}$ in. by $1\frac{1}{4}$ in.

It is quite evident that the agency which has effected the transformation of the wollastonite into nearly pure silica is merely that of the

surface waters percolating down through the mass of wollastonite and decomposing the silicate exclusively through the action of their dissolved carbonic acid. In some cases veinlets are found in the wollastonite mass full of secondary calcite or quartz, and more rarely both quartz and calcite are found crystallized side by side in the same veinlet, both evidently derived from the surrounding wollastonite by the agency of the percolating surface waters.

The following crystallographic details, determined on specimens now in the British Museum, have been supplied by Mr. L. J. Spencer:—

The large and somewhat roughly developed crystals of wollastonite from Mexico are elongated in the direction of the axis of symmetry, and the faces in this prismatic zone are deeply striated in the same direction. They are usually attached at one end, only one doubly terminated crystal being observed. There are perfect cleavages parallel to a (100) and c (001), from which fairly good measurements could be obtained, the mean of twenty-one readings being $ac = 84° 37'$. A few crystals are twinned on a (100), giving rise to a small salient or re-entrant angle (measured 10° 44′) between two c cleavages. The forms prominently developed and which could be determined with certainty are[1]:—$a\{100\}$, $c\{001\}$, $v\{101\}$, $t\{\bar{1}01\}$, $r\{301\}$, $q\{340\}$; these are shown in the accompanying figures. The hemihedral development of the crystal represented in the second of these figures is not due to twinning, as is the case with another crystal of very similar appearance. The third figure represents a twinned crystal.



Wollastonite crystals from Mexico.
(Orthogonal projections on the plane of symmetry.)

The plane of the optic axes coincides with the plane of symmetry, and the sign of the double refraction is negative. Through a cleavage flake parallel to a there emerges an optic axis outside the field of view (¼ inch objective in oil), and through the c cleavage is seen, towards the edge of the field, the set of rings around the second axis. The acute bisectrix lies in the acute[2] axial angle β, and is inclined at

[1] Letters and indices as in Dana's 'System of Mineralogy,' 6th edit., 1892.

[2] Not in the obtuse axial angle, as incorrectly quoted from Des Cloizeaux by Dana and in Rosenbusch's 'Rock-making Minerals' (2nd German, and 1st–4th English, editions).

only a few degrees to the normal to $t(\bar{1}01)$; through this plane the optic figure is thus seen nearly centrally. The axial angle in cedar oil was approximately measured with a stage-goniometer as $2H = 40°$.

In attempting to cut sections parallel to a plane of symmetry, the material readily broke up into fine fibres perpendicular to this plane. This almost fibrous structure of the crystals is perhaps due, not so much to the perfect cleavages, as to the presence of numerous, very fine, tubular cavities. These cavities are arranged parallel to the axis of symmetry, and are much elongated in this direction: under a high magnification some were seen to contain liquid and a bubble of gas.

Wollastonite with Bornite. In the ore-bodies near the edges of the mass, the essentially parallel development of the crystalline fibres of the wollastonite gives place to a confused network of small interpenetrating crystals, between which small crystals of bornite, chalcopyrite, and garnet have developed. This forms the ordinary concentrating ore worked in the mine, and it clearly exhibits the way in which the metallic and other impurities in the mass were eliminated during its cooling, so as to leave in the central portion nothing but pure silicate of lime. In other parts of the ore-bodies the impurities have been concentrated to a much higher degree, so as to produce masses of garnet mixed with copper minerals which are rich enough to be treated by direct smelting to regulus.

It may be remarked that the whole of the copper minerals carry precious metals, each ton of fine copper in the product of the mine containing on an average 9 ozs. gold and 160 ozs. silver.

Chalcedony containing Bornite. One small mass of this material was found forming the filling of a cavity in the wollastonite. It appears as a solidified jelly of grey semi-transparent chalcedony with minute spots of bornite.

Opal. In some places close to the outskirts of the wollastonite mass, and along lines of fissuring which run in a curved direction following the exterior of the mass, the processes of solution of lime and redeposition of silica have gone so far as to leave nothing but a mass of semi-opal, more or less stained by iron oxide and copper carbonate, which occasionally attains a width of two or three feet.

Garnet. Like most of the garnet found all over Mexico associated with contact-zones between porphyries and limestones, this is an aluminous andradite. It is found in rhombic dodecahedral crystals embedded in the wollastonite and in small cavities. In colour it varies from olive-green to resin-yellow and reddish-brown, but crystals of the different colours vary very little in chemical composition, as shown by the following partial analyses:—

	Green.	Brown.	All colours.
Silica	36·10	36·48	36·35
Alumina	—	—	12·37
Ferric oxide ...	19·30	19·50	19·43
Lime	—	—	33·33
Magnesia ...	—	—	0·40
			101·88

The average of a number of determinations of the specific gravity gave 3·89, which is higher than one would expect from the chemical composition.

Auriferous Linnaeite. In some of the massive bornite, as well as in some of the mixed rock from the ore-bodies carrying copper minerals, but always in very close association with the bornite, grains of a brittle, steel-grey mineral are sometimes found, and these on analysis turned out to be linnaeite (the nickeliferous variety, siegenite). A number of grains of the mineral were carefully picked out under the lens so as to be free from intermingled grains of bornite, and a portion of the picked mineral submitted to analysis, with the following results:—

Sulphur	44·31
Cobalt	29·64
Nickel	17·15
Iron	3·32
Copper	5·32
Gold	0·53 (=173 ozs. per ton)
Silver	0·13 (= 42 „)
Insoluble residue (quartz)	0·43
	100·83

Arsenic, antimony, bismuth, and tellurium were searched for but not found. The above figures agree closely with the formula

$$(Ni,Cu,Fe,Co)S.CoS_2.$$

The peculiarity of this mineral is in its gold and silver contents. It is often found associated with free gold, and the small specimens pulverized for analysis left, upon a screen of 120 meshes to the inch, metallic gold in amount equivalent to over 200 ozs. per ton. The author believes, however, that a portion of both the gold and silver contents occur in a chemically combined condition, replacing the other metals, since they cannot be wholly separated from the mineral by amalgamation[1], and suggests that they exist as sulphides replacing cobalt.

[1] Details of the experiments are given in Trans. Inst. Mining and Metallurgy, 1900, vol. viii, p. 304.

Enargite. This mineral is met with in parts of the ore-bodies near the present surface, where abundant evidence of secondary enrichment is forthcoming in connexion with extensive deposition of calcite and of massive bornite. It forms small, brilliant black crystals bounded by the macropinacoid $a\{100\}$, prism $m\{110\}$, and basal pinacoid $c\{001\}$, all of which are about equally developed. The crystals are quite short in the direction of the vertical crystallographic axis c, and are not, as is usually the case in enargite, attached at one end of this axis. They are frequently arranged in stellate twinned groups of three individuals intercrossing at approximately 60°. The crystals sometimes occur on quartz in cavities, but more generally investing masses of bornite.

Interlamination of Bornite and Galena. This peculiar occurrence, which the author believes to be unique, is very rare, only two or three specimens having been met with. The first specimen found, which was also by far the largest, was met with as a nodule in a mass of soft, decomposed, ochreous material containing garnet and quartz, which formed the outcrop of one of the ore-bodies occurring near a contact of wollastonite with felsite-porphyry. Diligent search was subsequently made for this mineral in unaltered portions of the ore-body immediately below, and was rewarded by finding several small nodules in pure unaltered wollastonite, the largest of which is about the size of a hazel-nut. The material is very rich in the precious metals, a specimen assayed containing at the rate of 14 ozs. gold and 108 ozs. silver per ton.

This peculiar interlamination reminds one of graphic granite, or of the inter-crystallization of some of the felspars. Most of all does it resemble the structure of eutectic alloys as exhibited by micro-photographs of polished surfaces under a magnifying power of several hundred diameters; in fact, except as to scale, the form and arrangement of the interlaminations are absolutely identical.

Idocrase in Crystalline Limestone.

Near the top of a limestone peak, about one and a half miles south of Santa Fé, very difficult of access and covered by dense bush, is a small outcrop of a coarsely crystallized rock, which consists largely of crystals of idocrase set in a matrix of calcite. The crystals of idocrase are stout prisms from $\frac{3}{4}$ to $1\frac{1}{4}$ inch in length, of a dark yellowish-green to leek-green colour, and almost invariably coated with scales of talc. They show the forms $m\{110\}$ and $p\{111\}$, with subordinate $a\{100\}$.

A (third) list of new mineral names[1].

By L. J. Spencer, M.A., F.G.S.

Assistant in the Mineral Department of the British Museum.

Alkali-garnet. W. C. Brögger and H. Bäckström, Zeits. Kryst. Min., 1890, vol. xviii, p. 215 (Alkaligranate, *pl.*). A general term for members of the sodalite group; these being closely related crystallographically and chemically to the true garnets. (Cf. the artificial lagoriolite = natrongranat of J. Morozewicz, 1898.)

Amianthinite. R. Kirwan, Elements of Mineralogy, 2nd edit., 1794, vol. i, p. 164. Asbestiform actinolite.

Ammonium-analcite, Ammonium-leucite, Ammonium-natrolite, Ammonium-stilbite, &c. F. W. Clarke and G. Steiger, Amer. Journ. Sci., 1900, ser. 4, vol. ix, pp. 117, 345; ibid., 1902, vol. xiii, p. 27; Bull. U. S. Geol. Survey, 1902, No. 207. Artificial derivatives of analcite, &c., with ammonium in place of sodium, potassium, or calcium.

Anapaite. A. Sachs, Sitz.-ber. Akad. Wiss. Berlin, 1902, p. 18; Zeits. angew. Chem., 1902, vol. xv, p. 111; 80er Jahres-Ber. Schlesisch. Ges., for 1902, 1903, Abt. II, Sect. *a*, p. 3 (Anapait). J. Loczka, Zeits. Kryst. Min., 1903, vol. xxxvii, p. 438. Pale green, glassy crystals on limonite, from Anapa, Black Sea. Anorthic. $FeCa_2(PO_4)_2 . 4H_2O$. Differs from messelite only in containing a little more water. *See* tamanite.

Anemolite. J. Barnes and W. F. Holroyd, Trans. Manchester Geol. Soc., 1896, vol. xxiv, p. 232 (anemolites). A curved and upturned form of stalactite of calcium carbonate from the Derbyshire limestone caves. Named from ἄνεμος, wind, and λίθος, stone, because of the

[1] The two preceding lists of this series will be found at the ends of vols. xi and xii of this Magazine. A few earlier names, omitted from Dana's 'System of Mineralogy' (6th edit., 1892) and Chester's 'Dictionary of the Names of Minerals' (1896), are included. Certain less accessible names, more especially in Russian literature, have been very kindly supplied by Professor W. Vernadsky, of Moscow. The original spelling of a name, as printed on the page cited, is added in parentheses whenever it differs from the spelling adopted in this list; the case-endings of Russian names have, however, been altered to the nominative.

influence of varying currents of air in determining the direction which the stalactites take.

Ankylite. G. Flink, Meddelelser om Grönland, 1901, Hefte xxiv, plate III. [The reprint of Flink's paper is dated 1899, but was not issued till 1900; Hefte xxiv is dated 1901.] The same as ancylite.

Antimon-luzonite. S. Stevanović, Zeits. Kryst. Min., 1903, vol. xxxvii, p. 235 (Antimon-Luzonit, Stibio-Luzonit). A massive mineral, with a reddish colour and absence of cleavage, from Peru. In composition, $Cu_3(As,Sb)S_4$, it is intermediate between luzonite and famatinite. It is identical with the 'famatinite' from Chile analysed by A. Frenzel in 1875.

Arsensulfurite. F. Rinne, Centralblatt Min., 1902, p. 499 (Arsensulfurit). Amorphous sulphur containing much arsenic (29·22 per cent.). A volcanic sublimation from Java.

Artinite. L. Brugnatelli, Rend. Ist. Lombardo, 1902, ser. 2, vol. xxxv, p. 874; Centralblatt Min., 1903, p. 144. A loose aggregate of snow-white scales which are composed of minute prismatic crystals. The optical characters agree with orthorhombic symmetry. In composition, $MgCO_3 . Mg(OH)_2 . 3H_2O$, near to hydrogiobertite, which, however, is shown to be a mixture of at least two minerals. In peridotite from the Val Lanterna, Val Tellina. Named after Prof. Ettore Artini, of Milan.

Badenite. P. Poni, Ann. Sci. Univ. Jassy, 1900, vol. i, p. 29; Anal. Acad. Române, Bukarest, 1900, vol. xxii; (abstract, this vol., p. 207). A massive steel-grey mineral which appears to be smaltite (or safflorite) with part of the arsenic replaced by bismuth (4·76 per cent.); $(Co,Ni,Fe)_2(As,Bi)_3$. From Badeni, Roumania.

Bakerite. W. B. Giles, Min. Mag., 1903, vol. xiii, p. 353. A massive borosilicate of calcium, $8CaO . 5B_2O_3 . 6SiO_2 . 6H_2O$, from the borax mines of California. Named after Mr. R. C. Baker, of Nutfield (Surrey), by whom the mineral was found.

Baumhauerite. R. H. Solly, Min. Mag., 1902, vol. xiii, p. 151; 1903, vol. xiii, p. 339; Zeits. Kryst. Min., 1903, vol. xxxvii, p. 321. Crystals resembling in general appearance the several other sulpharsenites of lead from the Binnenthal dolomite. Monoclinic. $4PbS . 3As_2S_3$. Named after Professor Heinrich Baumhauer, of Freiburg, Switzerland.

Bavenite. E. Artini, Rend. Accad. Lincei, Roma, 1901, ser. 5,

vol. x, sem. 2, p. 139. Radiating tufts of white needles in the drusy cavities of the Baveno granite. Monoclinic, but twinned to simulate orthorhombic symmetry. $3CaO \cdot Al_2O_3 \cdot 6SiO_2 \cdot H_2O$. Approaches pilinite in composition.

Bleimalachit. S. F. Glinka, Centralblatt Min., 1901, p. 281. Acicular crystals of orthorhombic habit, but monoclinic and twinned. $2CuCO_3 \cdot Cu(OH)_2 \cdot PbCO_3$. Altai Mountains. *See* plumbomalachite.

Bleizinkchrysolith. P. P. Heberdey, Zeits. Kryst. Min., 1892, vol. xxi, p. 56. An artificial product (from a crystallized slag) with the composition $PbZnSiO_4$ and isomorphous with chrysolite.

Bodenzeolith. *See* geolyte.

Boothite. W. T. Schaller, Bull. Dep. Geol. Univ. California, 1903, vol. iii, p. 207. A copper sulphate with $7H_2O$, instead of $5H_2O$ as in chalcanthite; $CuSO_4 \cdot 7H_2O$. Monoclinic, and isomorphous with melanterite. Occurs with other sulphates as an alteration product of chalcopyrite in the Alma mine, Leona Heights, Alameda Co., California. Named after Mr. Edward Booth, of the University of California.

Bourgeoisite. R. Breñosa, Anal. Soc. Española Hist. Nat., 1885, vol. xiv, p. 129 (Bourgeoisita). Described as a tetragonal modification of calcium silicate dimorphous with wollastonite. In a devitrified glass of doubtful origin. Named after Dr. L. Bourgeois, of Paris.

Breadalbanite. (Catalogue of the Mineral Collections in the Museum of Practical Geology. By W. W. Smith and others. London, 1864, p. 180.) A variety of hornblende from Perthshire, Scotland. T. Egleston (Catalogue of Minerals and Synonyms, Washington, 1887, Bull. U. S. National Mus., 1889, No. 33) gives breadalbaneite (p. 13) and breadalbanite (p. 33).

Brostenite. P. Poni, Ann. Sci. Univ. Jassy, 1900, vol. i, p. 53; Anal. Acad. Române, Bukarest, 1900, vol. xxii; (abstract, this vol., p. 207). Black friable masses occurring as an alteration product of rhodochrosite, near Brosteni, Roumania. The results of three analyses show it to be a hydrated manganite of iron and manganese near chalcophanite, but of variable composition.

Brunsvigite. J. Fromme, Min. petr. Mitt. (Tschermak), 1902, vol. xxi, p. 171 (Brunsvigit). A chloritic mineral, near metachlorite, occurring as fine scaly masses in the gabbro of Radauthal, Harz (Brunswick).

Ceruleite. H. Dufet, Bull. Soc. franç. Min., 1900, vol. xxiii, p. 147 (céruléite). Turquoise-blue, clayey masses. Under the microscope it is seen to be minutely crystalline. $CuO . 2Al_2O_3 . As_2O_5 . 8H_2O$. Huanaco, Chile. Named from the Latin, *caeruleus*, sky-blue.

Chalmersite. E. Hussak, Centralblatt Min., 1902, p. 69 (Chalmersit). Brilliant, bronze-yellow, acicular crystals very similar to copper-glance in habit, twinning, and angles; they are magnetic like pyrrhotite. Orthorhombic. $CuFe_3S_4 = Cu_2S . Fe_6S_7$ (but only 0·016 gram of material analysed). Associated with pyrrhotite, &c. at the Morro Velho gold-mine, Minas Geraes, Brazil. Named after Mr. G. Chalmers, the superintendent of the mine.

Chocolate-stone. *See* lacroisite.

Chromocyclite. C. Klein, Jahrb. Min., 1892, vol. ii, pp. 176, 220 (Chromocyclit); C. Hintze, Handb. d. Min., 1897, vol. ii, p. 1733 (Chromocyklit). Apophyllite which shows coloured interference rings in convergent polarized light, as distinct from the black and white rings of the leucocyclite variety.

Ciempozuelite. A. de Areitio y Larrinaga, Anal. Soc. Española Hist. Nat., 1873, vol. ii, p. 393 (Ciempozuelita). $3Na_2SO_4 . CaSO_4$. From the salt mines at Ciempozuelos, Madrid. [Possibly a mixture of glauberite ($Na_2SO_4 . CaSO_4$) and thenardite (Na_2SO_4), both of which occur at this locality.]

Clinoaugite. *See* orthoaugite.

Clinopyroxene. *See* orthoaugite.

Coolgardite. A. Carnot, Compt. rend. Acad. Sci., Paris, 1901, vol. cxxxii, p. 1300; Bull. Soc. franç. Min., 1901, vol. xxiv, p. 360; Ann. des Mines, sér. 9, vol. xix, p. 533. Described as a sesquitelluride of gold, silver, and mercury from Kalgoorlie, East Coolgardie gold-field, Western Australia. Proved to be a mixture of coloradoite (HgTe), and the gold and silver tellurides, calaverite, sylvanite, and petzite (L. J. Spencer, Min. Mag., 1903, vol. xiii, p. 268).

Ctypeite. Bull. Soc. franç. Min., 1901, vol. xxiv, p. 456, abstracts (ctypéite). The same as ktypeite (A. Lacroix, 1898).

Cumengite. P. Groth, Tab. Uebers. d. Min., 1898, 4th edit., p. 55 (Cumengit); E. S. Dana, 1st appendix to the 6th edit. of Dana's System of Mineralogy, 1899, p. 21. The same as the cumengeite of Mallard (1893, named after Mr. E. Cumenge); not the cumengite of Kenngott (1853).

Diestit. Zeits. Kryst. Min., 1901, vol. xxxiv, p. 720; Chem. Central-Blatt, 1901, Jahrg. 72, vol. ii, p. 828. The same as vandiestite (q. v.).

Discachatae. M. F. Heddle, Trans. Geol. Soc. Glasgow, 1900 [1901], vol. xi, pp. 167–9; Heddle, Mineralogy of Scotland, 1901, vol. i, pp. 70–2 (Discachatæ). This and other names (haemachatae, haema-ovoid-agates, oonachatae) are proposed for structural varieties of agate, defined by the enclosure of discoidal or ovoidal patches of cacholong, &c., sometimes of a red colour.

Eglestonite. A. J. Moses, Amer. Journ. Sci., 1903, ser. 4, vol. xvi, p. 253. Cubic oxychloride of mercury, $Hg_6Cl_3O_2$. The brownish-yellow colour of the crystals quickly changes to black on exposure to light. Named after the late Professor Thomas Egleston, of Columbia University, New York. *See* terlinguaite.

Eisencordierit. H. Bücking, Ber. Senckenberg. Naturf. Ges. Frankfurt-am-Main, 1900, p. 15. Cordierite with magnesia largely replaced by ferrous iron, as is the case in the cordierite of the 'vitrified' sandstones altered by contact with basalt in central Germany.

Eisenrömerit. *See* ferrorömerite.

Erzbergite. E. Hatle, Mitth. naturwiss. Ver. Steiermark, 1892, vol. xxviii (Jahrg. 1891), p. 295 (Aragonit-Calcit-Sinterbildungen (Erzbergit)). A calcareous deposit from Erzberg, Eisenerz, Styria, consisting of alternate layers of calcite and aragonite.

Esmeraldaite. A. S. Eakle, Bull. Dep. Geol. Univ. California, 1901, vol. ii, p. 320. Pod-shaped masses of a coal-black colour and bright vitreous lustre; it has a glassy fracture, and in thin splinters transmits yellowish-red light; streak, yellowish-brown. The mean of several analyses gives, after deducting 17 per cent. of impurities, the formula $Fe_2O_3 . 4H_2O$. Found in earthy limonite in Esmeralda Co., Nevada.

Ferropallidite. R. Scharizer, Zeits. Kryst. Min., 1903, vol. xxxvii, p. 547 (Ferropallidit). A white, granular ferrous sulphate, $FeSO_4 . H_2O$, occurring with römerite in Chile. Named from *ferrum*, iron, and *pallidus*, pale.

Ferrorömerite. R. Scharizer, Zeits. Kryst. Min., 1903, vol. xxxvii, p. 546 (Eisenrömerit, Ferrorömerit). A synonym of römerite. *See* zinc-römerite.

Geolyte. E. A. Wülfing, Jahreshefte Ver. vaterl. Naturk. Württemberg, 1900, vol. lvi, p. 35 (Geolyt). To replace the term 'Bodenzeolith'

used by agricultural chemists for those constituents of soils which are readily soluble and of indefinite mineralogical composition, but have little in common with zeolites. Named from γῆ, earth, and λύειν, to dissolve.

Grandidierite. A. Lacroix, Bull. Soc. franç. Min., 1902, vol. xxv, p. 86. A blue, sapphirine-like mineral in granite from Madagascar. Orthorhombic, with strong pleochroism. Sp. gr. = 2·99. A basic silico-aluminate of iron, magnesium, and calcium with 2 per cent. of alkalies. Named after Mr. Alfred Grandidier, an authority on the geography and natural history of Madagascar.

Hackmanite. L. H. Borgström, Geol. För. Förh. Stockholm, 1901, vol. xxiii, p. 563 (Hackmanit). A member of the sodalite group occurring as rhombic dodecahedral crystals of a pale reddish-violet colour in a rock called tawite from the Tawa valley, Kola peninsula, Lapland. It has the composition of sodalite, $Na_4(AlCl)Al_2(SiO_4)_3$, but contains in addition 6·23 per cent. of $Na_4[Al(NaS)]Al_2(SiO_4)_3$, a compound which Brögger and Bäckström (1890) concluded to be a constituent of the artificial product known as 'white ultramarine.' The sulphur is present as monosulphide, and not as polysulphide as in lazurite. Named after Dr. Victor Hackman, of Helsingfors.

Haemachatae. *See* discachatae.

Haema-ovoid-agates. *See* discachatae.

Hellandite. W. C. Brögger, Nyt Mag. Naturvid. Kristiania, 1903, vol. xli, p. 213 (Hellandit). Monoclinic crystals in the pegmatite-veins near Kragerö, Norway; they are much altered; the freshest contained 7·55 per cent. of water and were optically isotropic (like gadolinite, orthite, &c.). Probable formula: $Ca_2R_3'''(R'''O)_3(SiO_4)_4$, where R''' = Ce,Di,La,Al,Fe,Mn. Related to guarinite. Named after Professor Armund Helland, of Christiania.

Histrixite. W. F. Petterd, Papers and Proc. Roy. Soc. Tasmania for 1900–1, 1902, p. 77; ibid., for 1902, 1903, p. 24; Rep. Secr. Mines, Tasmania, for 1901–2, 1902, p. 294. Radiating groups of orthorhombic crystals, associated with chalcopyrite, bismuthinite, &c., at Ringville, Tasmania. Described as a sulphide of antimony and bismuth with the formula $7Bi_2S_3 . 2Sb_2S_3 . 5CuFeS_2$. [Probably a mixture.] Named histrixite (porcupine-ore) from the Latin, *hystrix* (*histrix*), a porcupine.

Hörnbergite. J. F. Vogl? (— Adam, Tableau Minéralogique, Paris, 1869, p. 42). An arsenate of uranium.

Huelvite. *See* lacroisite.

Hussakite. E. H. Kraus and J. Reitinger, Zeits. Kryst. Min., 1901, vol. xxxiv, p. 268 (Hussakit); (abstract, this vol., p. 307). E. Hussak and J. Reitinger, Zeits. Kryst. Min., 1903, vol. xxxvii, p. 563. A synonym of xenotime. Named after Dr. Eugen Hussak, of the Geological Survey of São Paulo, Brazil.

Hydrogöthite. P. A. Zemĭatčenskij, Trav. Soc. Nat. St.-Pétersbourg, 1889, vol. xx, Sect. Géol. et Min., p. 208 (*иодроземитъ*); (abstract, Zeits. Kryst. Min., 1892, vol. xx, p. 185). J. Samojlov, Zeits. Kryst. Min., 1901, vol. xxxv, p. 272. A fibrous (crystalline), cochineal-red hydroxide of iron, $3Fe_2O_3 . 4H_2O$, occurring as veins in limonite in central Russia.

Iodembolite. G. T. Prior and L. J. Spencer, Centralblatt Min., 1902, p. 186 (Jodembolit); Min. Mag., 1902, vol. xiii, p. 176 (iodiferous embolite or iodembolite). To replace the name iodobromite ($2AgCl . 2AgBr . AgI$, which has no existence as a definite compound), and as a general term for minerals of the cerargyrite group (holohedral-cubic silver haloids) containing chlorine, bromine, and iodine, Ag(Cl,Br,I).

Kali-Harmotom. L. Gmelin, Leonhard's Zeits. Min., 1825, vol. i, p. 11. Synonym of phillipsite.

Kalkeisencordierit. H. Bücking, Ber. Senckenberg. Naturf. Ges. Frankfurt-am-Main, 1900, p. 7. Cordierite with lime and ferrous oxide in place of magnesia. In ejected volcanic blocks from the Celebes.

Keweenawite. G. A. Koenig, Amer. Journ. Sci., 1902, ser. 4, vol. xiv, p. 410. A massive, finely-granular mineral, with a pale pinkish-brown colour and metallic lustre, from the Mohawk mine, Keweenaw Co., Michigan. Analyses agree approximately with the formula $(Cu,Ni,Co)_2As$. *See* mohawkite.

Klinoaugit. *See* orthoaugite.

Klino-pyroxen. *See* orthoaugite.

Koenenite. F. Rinne, Centralblatt Min., 1902, p. 493 (Koenenit). A red, scaly mineral with a perfect micaceous cleavage, from the salt deposits of Volpriehausen, Hanover. Rhombohedral, optically uniaxial and positive. $Al_2O_3 . 3MgO . 2MgCl_2 . 6(\text{or } 8)H_2O$. Named after Professor Adolf von Koenen, of Göttingen.

Kunzite. C. Baskerville, Science, New York, 1903, n. ser., vol. xviii, p. 303. G. F. Kunz, Science, New York, 1903, vol. xviii, p. 280; Amer.

Journ. Sci., 1903, ser. 4, vol. xvi, p. 264. A lilac-coloured gem-variety of spodumene from California. Named after Dr. George Frederick Kunz, of New York.

Lacroisite. H. Lienau, Chemiker-Zeitung, 1903, Jahrg. xxvii, p. 15 (Lacroisit). Torrensite and viellaurite, from manganese mines in the Pyrénées, previously described as new minerals by Lienau (ibid., 1899, Jahrg. xxiii, p. 418), have been shown on microscopical examination by A. Lacroix (Bull. Soc. franç. Min., 1900, vol. xxiii, p. 251) to be mixtures of various manganese minerals (mainly rhodochrosite, tephroite, and rhodonite). Lienau now describes other similar mixtures under the names lacroisite (a mixture of rhodochrosite and rhodonite; named after Professor Alfred Lacroix, of Paris), Schokoladenstein (chocolate-stone), and huelvite (from Huelva, Spain).

Lardite. P. A. Zemĭatčenskij, Trav. Soc. Nat. St.-Pétersbourg, 1889, vol. xx, Sect. Géol. et Min., p. 216 (*лардитъ*); (abstract, Zeits. Kryst. Min., 1892, vol. xx, p. 185). Hydrated silica occurring in clay in central Russia; while still moist it is white and slightly transparent, but on drying it becomes opaque. Named from the Latin, *lardum*, lard. The name lardite was used by J. G. Wallerius in 1788 for steatite. *See* ljardit.

Lassallite. G. Friedel, Bull. Soc. franç. Min., 1901, vol. xxiv, p. 6. A substance resembling matted asbestos, which, under the microscope, is seen to consist of birefringent fibres. $3MgO \cdot 2Al_2O_3 \cdot 12SiO_2 \cdot 8H_2O$. France. Named after M. Lassalle, a mine proprietor.

Ledouxite. J. W. Richards, Amer. Journ. Sci., 1901, ser. 4, vol. xi, p. 458; Chem. News, 1901, vol. lxxxiv, p. 29. The copper arsenide $(Cu,Ni,Co)_4As$, analysed by Dr. Ledoux, and previously named mohawkite (q. v.).

Leukosphenite. G. Flink, Meddelelser om Grönland, 1901, Hefte xxiv, plate VII. The same as leucosphenite.

Liveingite. R. H. Solly, Proc. Cambridge Phil. Soc., 1901, vol. xi, p. 239; Min. Mag., 1902, vol. xiii, p. 160 footnote; (abstract, this vol., p. 206). Crystals resembling in general appearance the several other sulpharsenites of lead from the Binnenthal dolomite. Monoclinic. $5PbS \cdot 4As_2S_3$. Named after Professor G. D. Liveing, of Cambridge.

Ljardit. (Neues Jahrb. Min., 1901, vol. ii, –408–, abstracts.) The same as lardite (q. v.).

Lotrite. G. Munteanu-Murgoci, Bull. Soc. Sci. Bukarest, 1900, vol. ix, p. 596; 1901, vol. ix, p. 783; Inaug.-Diss. München, 1901 (Lotrit). A constituent of an epidote-schist occurring in contact with serpentine in the Lotru valley, southern Carpathians. $3(Ca,Mg)O_2.Al_2O_3.4SiO_2.2H_2O$. Very similar to prehnite, but differs slightly from this in optical characters, as determined under the microscope in rock-sections.

Macrolepidolite. H. Baumhauer, Eclogae geol. Helvetiae, 1903, vol. vii, p. 354. Two varieties of lepidolite, one with a large optic axial angle, and the other with a small angle, are distinguished and called respectively macrolepidolite and microlepidolite (Makrolepidolith and Mikrolepidolith); the two varieties also differ in the character of the etched figures on the cleavage planes.

Malachite de plomb. (Internat. Catal. Sci. Liter., 1903, Mineralogy volume for 1901, p. 108.) *See* plumbomalachite.

Manganosphaerite. K. Busz, Neues Jahrb. Min., 1901, vol. ii, p. 129 (Manganosphärit). Resembles sphaerosiderite in appearance, but has the composition of oligonite ($3FeCO_3.2MnCO_3$), from which it only differs in being not in crystals. In cavities in a basalt-vein at Horhausen, Rhenish Prussia. [The name would suggest either a botryoidal manganese carbonate or a manganiferous sphaerite (hydrated basic aluminium phosphate).]

Melanochalcite. G. A. Koenig, Amer. Journ. Sci., 1902, ser. 4, vol. xiv, p. 404. A pitch-black, amorphous mineral occurring as thin bands in nodules composed of cuprite, malachite, chrysocolla, and quartz at Calumet, near Bisbee, Arizona. A basic silico-carbonate of copper, $Cu_2(Si,C)O_4.Cu(OH)_2$. Named from μέλας, μέλανος, black, and χαλκός, copper.

Mesolitine. J. Apjohn, Journ. Geol. Soc. Dublin, 1844, vol. iii, p. 77. Identical with thomsonite. Named mesolitine because of a supposed relation to mesolite.

Metachalcolite. Bull. Soc. franç. Min., 1902, vol. xxv, p. 372 (abstract of Rinne's paper). Synonym of metakupferuranit (q. v.).

Metakalkuranit. F. Rinne, Centralblatt Min., 1901, p. 709 (Metakalkuranite, *pl.*). Calco-uranite (autunite) from which part of the water has been artificially expelled by heating, thus causing an important series of changes in the optical characters.

Metakoenenite. F. Rinne, Centralblatt Min., 1902, p. 498 (Metakoenenit). Koenenite (q. v.) when heated in water leaves a residue

having the composition $Al_2O_3 . MgO . H_2O$; with ammonium chloride solution it yields $Al_2O_3 . 2H_2O$, and this on ignition gives anhydrous alumina. These artificially produced secondary products ('metakoenenites') retain the scaly form of the original mineral, and are optically uniaxial and negative.

Metakupferuranit. F. Rinne, Centralblatt Min., 1901, p. 618 (Metakupferuranite, *pl.*). Cupro-uranite (torbernite) from which part of the water has been artificially expelled by heating, thus causing an important series of changes in the optical characters. *See* metachalcolite.

Microlepidolite. *See* macrolepidolite.

Mohawk-algodonite. G. A. Koenig, Amer. Journ. Sci., 1902, ser. 4, vol. xiv, pp. 414, 416. Massive copper arsenides from the Mohawk mine, Michigan, of variable composition, but approximating to that of algodonite. *See* mohawkite.

Mohawkite. J. R. Stanton, Engin. and Mining Journ. New York, 1900 (April), vol. lxix, p. 413. A massive copper arsenide, with some cobalt and nickel, from the Mohawk mine, Michigan. Ledoux deduced from his analysis the formula $(Cu,Ni,Co)_4As$. This was afterwards re-named ledouxite (q. v.).

G. A. Koenig, Amer. Journ. Sci., 1900 (December), ser. 4, vol. x, p. 440; Zeits. Kryst. Min., 1901, vol. xxxiv, p. 67. A nickeliferous and cobaltiferous domeykite, $(Cu,Ni,Co)_3As$, from the Mohawk mine. The copper arsenides from this locality show wide variations in composition, and, as pointed out by Koenig, are mixtures, or more of the nature of alloys rather than definite mineral species; nevertheless this author has introduced for them several other new names, viz.:—keweenawite, mohawk-algodonite, mohawk-whitneyite, and semi-whitneyite (q. v.).

Mohawk-whitneyite. G. A. Koenig, Amer. Journ. Sci., 1900, ser. 4, vol. x, p. 446; Zeits. Kryst. Min., 1901, vol. xxxiv, p. 75 (Mohawkit-Whithneyit); Amer. Journ. Sci., 1902, ser. 4, vol. xiv, pp. 414, 416. Intimate mixtures of mohawkite and whitneyite from the Mohawk mine, Michigan. *See* mohawkite.

Moldavite. P. Poni, Ann. Sci. Univ. Jassy, 1900, vol. i, p. 144; Anal. Acad. Române, Bukarest, 1900, vol. xii. Earlier used by Cobalcescu [reference ?] as a specific name for ozocerite, and later by C. Istrati (1897) [who, however, spells the word moldovite] for a variety of ozocerite from Moldavia (Moldova).

Molybdophyllite. G. Flink, Bull. Geol. Inst. Univ. Upsala, 1901, vol. v (1900), p. 91 (Molybdophyllit). Platy masses with a perfect basal cleavage, and having quite the appearance of white mica. Found with hausmannite in granular limestone or dolomite at Långban, Sweden. Hexagonal. $2(Pb,Mg)O \cdot SiO_2 \cdot H_2O$. Differs from barysilite in containing water. Named from μόλυβδος, lead, and φύλλον, a leaf.

Montroydite. A. J. Moses, Amer. Journ. Sci., 1903, ser. 4, vol. xvi, p. 259. Orthorhombic mercuric oxide, HgO, occurring as velvety encrustations of orange-red needles on mercury-ores at Terlingua, Texas. Named after Mr. Montroyd Sharpe, one of the owners of the mines.

Mooraboolite. G. B. Pritchard, Victorian Naturalist, 1901, vol. xviii, p. 63. A zeolite occurring as white, radial aggregates in the decomposed basalt of the Moorabool valley, Victoria. In chemical composition, and in the crystallographic and physical characters as far as determined, it agrees with natrolite.

Mouchketovite. Ann. Géol. et Min. Russie, 1901, vol. iv, sect. iii, p. 107 (Mouchkétovite, Мушкетовитъ). The same as muschketowit (E. S. Fedorov and W. Nikitin, 1899).

Narsasukite. G. Flink, Meddelelser om Grönland, 1901, Hefte xxiv, plate VIII, and p. 154 footnote. Error for narsarsukite.

Natroalunite. W. F. Hillebrand and S. L. Penfield, Amer. Journ. Sci., 1902, ser. 4, vol. xiv, pp. 218, 220; Zeits. Kryst. Min., 1902, vol. xxxvi, pp. 552, 554. Alunite with part of the potash replaced by soda; in material from Colorado $K_2O : Na_2O = 4 : 7$. $(Na,K)_2[Al(OH)_2]_6(SO_4)_4$. Rhombohedral.

Natrojarosite. W. F. Hillebrand and S. L. Penfield, Amer. Journ. Sci., 1902, ser. 4, vol. xiv, p. 211; Zeits. Kryst. Min., 1902, vol. xxxvi, p. 545. A yellowish-brown, glistening powder consisting wholly of minute, perfectly developed rhombohedra with basal planes. $Na_2[Fe(OH_2]_6(SO_4)_4$. From Soda Springs Valley, Nevada.

Natronkalisimonyit. R. Köchlin, Min. petr. Mitt. (Tschermak), 1902, vol. xxi, p. 356. A provisional name for crystals agreeing with blödite (simonyite) in form, but apparently differing slightly in chemical composition: in addition to soda, a little potash (0·43 per cent.) is present, and more water is expelled at 100° C. than from typical blödite. From the salt deposits of Kalusz, Galicia.

Natronphlogopit. E. Weinschenk, Abhandl. Akad. Wiss. München,

1901, vol. xxi, p. 272. A white mica containing magnesia and soda (and potash) in crystalline limestone from Styria.

Neotantalite. P. Termier, Bull. Soc. franç. Min., 1902, vol. xxv, p. 34 (Néotantalite). Minute, regular octahedra resembling pyrochlore, in kaolin from dép. Allier, France. Hydrated tantalate (and niobate) of iron, manganese, and alkalies. Considered to be a dimorphous form of tantalite, but differs considerably from this in composition.

Oonachatae. *See* discachatae.

Orthoaugite. F. Rinne, Sitz.-ber. Akad. Wiss. Berlin, 1900, p. 482 (Orthoaugit). A collective name for the orthorhombic pyroxenes, enstatite, bronzite, and hypersthene, which cannot always be distinguished from each other in rock-sections. Similarly, monoclinic pyroxenes are called clinoaugites (Klinoaugite).

Following Rinne, E. Düll (Zeits. Kryst. Min., 1902, vol. xxxvi, p. 654 footnote, abstract) proposes the terms ortho-pyroxene and klino-pyroxene, abbreviated as o-pyroxene and kl-pyroxene.

Palacheite. A. S. Eakle, Bull. Dep. Geol. Univ. California, 1903, vol. iii, p. 231. Loosely coherent aggregates of brick-red, monoclinic crystals, found as a recent formation in the old workings of the Redington mercury mine, Knoxville, California. $2MgO . Fe_2O_3 . 4SO_3 . 15H_2O$. It is not proved to differ essentially from the imperfectly determined rubrite. Named after Dr. Charles Palache, of Harvard University.

Petricichite. P. Poni, Ann. Sci. Univ. Jassy, 1900, vol. i, p. 143; Anal. Acad. Române, Bukarest, 1900, vol. xxii. Error (?) for pietricikite, which is given by C. Istrati (Bull. Soc. Sci. Bukarest, 1897, vol. vi, p. 65) as the correct spelling of Dana's zietrisikite. A variety of ozocerite from Mount Pietricica, Moldavia.

Petterdite. W. H. Twelvetrees, Rep. Secr. Mines, Tasmania, for 1900–1, 1901, p. 356; Papers and Proc. Roy. Soc. Tasmania, for 1900–1, 1902, p. 51. An oxychloride of lead occurring in Tasmania as white, thin hexagonal plates. Named after Mr. W. F. Petterd, of Launceston, Tasmania.

Pigeonite. A. N. Winchell, Amer. Geologist, 1900, vol. xxvi, pp. 204, 368; Thèse Fac. des Sci. Paris, 1900. A pyroxene, with optic axial angle small and variable ($2E = 13° 16' - 62° 24'$), occurring as a constituent of olivine-diabase at Pigeon Point, Minnesota.

Plumbojarosite. W. F. Hillebrand and S. L. Penfield, Amer. Journ. Sci., 1902, s r. 4, vol. xiv, p. 213; Zeits. Kryst. Min., 1902, vol. xxxvi,

p. 548. A dark-brown, glistening powder consisting wholly of minute, perfectly developed rhombohedra with basal planes. $Pb[Fe(OH)_2]_6(SO_4)_4$. From Cook's Peak, New Mexico.

Plumbomalachite. S. F. Glinka and I. A. Antipov, St. Peterburg, Dnevn. XI Sjezda russ. jest. vrač., 1901, p. 468 (свинцовомъ малахитъ). *See* Bleimalachit, malachite de plomb.

Porcupine-ore. *See* histrixite.

Pseudomesolite. A. N. Winchell, Amer. Geologist, 1900, vol. xxvi, pp. 275, 372; Thèse Fac. des Sci. Paris, 1900. A zeolite agreeing with mesolite in chemical composition, but differing in optical characters. Occurs as colourless to white, radially fibrous masses in plagioclasite in Minnesota.

Pseudophillipsite. F. Zambonini, Neues Jahrb. Min., 1902, vol. ii, p. 73 (Pseudophillipsit). A zeolite, from the leucitic lavas near Rome, agreeing with phillipsite in form and twinning (though octahedral in habit, like gismondite), but containing less silica (38 per cent.) than typical phillipsite: formula, $(Ca,Na_2)_2Al_4Si_5O_{18}.9H_2O$.

Pyknochlorite. J. Fromme, Min. petr. Mitt. (Tschermak), 1903, vol. xxii, p. 62 (Pyknochlorit). A greyish-green, compact chlorite occurring in a quartz and calcite vein in the gabbro of the Radauthal, Harz. It has the same general formula (Sp_3At_4, Tschermak) as clinochlore, but differs from this in containing much more ferrous iron and in its compact (πυκνός) texture.

Revdinite. E. N. Kortkov, Bull. Soc. Ouralienne d'Amateurs des Sci. Nat., 1891-2, vol. xiii, pp. 83, 76 (ревдинитъ). The same as rewdanskit (R. Hermann, 1867); other forms of spelling are: refdanskite, revdanskite, revdinskite, rewdjanskit. An impure hydrous nickel silicate from Revda (= Revdinsk), Urals.

Rickardite. W. E. Ford, Amer. Journ. Sci., 1903, ser. 4, vol. xv, p. 69; Engin. and Min. Journ. New York, 1903, vol. lxxv, p. 113; Chem. News, 1903, vol. lxxxvii, p. 56; Zeits. Kryst. Min., 1903, vol. xxxvii, p. 609. A massive telluride of copper, Cu_4Te_3, with a rich purple colour resembling an iridescent tarnish. From Vulcan, Gunnison Co., Colorado. Named after Mr. T. A. Rickard, of New York. *See* sanfordite.

Sanfordite. Ores and Metals, Denver, Colorado, April, 1903 (Sandfordite in title). A synonym of the earlier name rickardite (q. v.). Named after Mr. Albert B. Sanford, of Denver, who first noticed the mineral in 1901.

Schertalite. R. W. E. MacIvor, Chem. News, 1902, vol. lxxxv, p. 217. To replace the name muellerite for a phosphate in bat guano from Skipton Caves, Ballarat, Victoria. Small, indistinct crystals with the composition $Mg(NH_4)_2H_2(PO_4)_2 . 4H_2O$. Named after Professor Arnulf Schertal, late of Freiberg, Saxony.

Schokoladenstein. *See* lacroisite.

Sclerospathite. W. F. Petterd, Rep. Secr. Mines, Tasmania, for 1901–2, 1902, p. 297; Papers and Proc. Roy. Soc. Tasmania, for 1902, 1903, p. 27. A hydrated sulphate of iron and chromium, perhaps allied to knoxvillite, occurring as tough (σκληρός), felted masses of short fibres, at Salisbury, Tasmania.

Seligmannite. H. Baumhauer, Sitz.-ber. Akad. Wiss. Berlin, 1901, p. 110 (abstract, this vol., p. 205); ibid., 1902, p. 611. R. H. Solly, Min. Mag., 1903, vol. xiii, p. 336. Crystals resembling in general appearance the several sulpharsenites of lead from the Binnenthal dolomite. Orthorhombic, with angles, habit, and twinning similar to those of bournonite, and probably therefore with the composition $Cu_2S . 2PbS . As_2S_3$. Named after Herr Gustav Seligmann, of Coblenz.

Semi-whitneyite. G. A. Koenig, Amer. Journ. Sci., 1902, ser. 4, vol. xiv, p. 416. Massive copper arsenides in which the ratio of Cu : As is variable and very high (up to 30 : 1). *See* mohawkite.

Serendibite. G. T. Prior and A. K. Coomáraswámy, Nature, 1902, vol. lxv, p. 383; Quart. Journ. Geol. Soc., 1902, vol. lviii, p. 420; Min. Mag., 1903, vol. xiii, p. 224. Blue, embedded crystals in the contact-zones between crystalline limestone and granulite. Probably anorthic; with polysynthetic twinning and strong pleochroism.

$$10(Fe,Ca,Mg)O . 5Al_2O_3 . 6SiO_2 . B_2O_3.$$

Named from 'Serendib,' an old Arab name for Ceylon, where the mineral was found.

Serpentin-Asbest. C. F. Naumann, Elem. d. Min., 2nd edit., 1850, p. 284. Synonym of chrysolite.

Silver-analcite, Silver-chabazite. G. Steiger, Amer. Journ. Sci., 1902, ser. 4, vol. xiv, p. 31. Artificial derivatives of analcite and chabazite with silver in place of sodium or calcium.

Speculite. E. H. Liveing, Engin. and Mining Journ., New York, 1903, vol. lxxv, p. 814. A specular gold and silver telluride from Kalgoorlie, Western Australia, resembling sylvanite in colour and perfect cleavage, but differing from this in chemical composition (Au 36, Ag 4 per cent.) and sp. gr. (8·64).

Stagmalite. O. C. Farrington, Field Columbian Museum, Chicago, Publication 53, Geol. Ser., 1901, vol. i, p. 261 (Stagmalites). A general term, to include both stalactite and stalagmite, for formations produced by dropping water. From *στάγμα*, a drop, and *λίθος*, a stone.

Steenstrupite. O. B. Boeggild, Meddelelser om Grönland, 1901, vol. xxiv, p. 203. The same as steenstrupine.

Stibio-domeykite. G. A. Koenig, Amer. Journ. Sci., 1900, ser. 4, vol. x, p. 445; Zeits. Kryst. Min., 1901, vol. xxxiv, p. 67. Massive domeykite containing a small amount of antimony (0·78 to 1·29 per cent.). From the Mohawk mine, Lake Superior copper region.

Stibio-luzonite. *See* antimon-luzonite.

Stoffertite. C. Klein, Sitz.-ber. Akad. Wiss. Berlin, 1901, p. 722 (Stoffertit). Differs from brushite ($HCaPO_4 . 2H_2O$) only in containing a little more water ($HCaPO_4 . 2\frac{3}{4}H_2O$). This difference is probably not essential, but, in case it should at some future time be proved to be so, the new name is provisionally given. From the guano deposits of the island of Mona, Porto Rico, West Indies. Named after Dr. Adolph Stoffert, of Hamburg, who sent the material for examination.

Sulfurite. F. Rinne, Centralblatt Min., 1902, p. 500 (Sulfurit). Naturally occurring amorphous sulphur. *See* arsensulfurite.

Synchysite. G. Flink, Bull. Geol. Inst. Univ. Upsala, 1901, vol. v (1900), p. 81 (Synchysit); abstract, this vol., p. 207. The mineral from Narsarsuk, Julianehaab, Greenland, previously described as parisite, has characters sufficiently distinct from those of the Colombian parisite to be regarded as a distinct species. Hexagonal. $CeFCa(CO_3)_2$. Named from *σύγχυσις*, confounding.

Taeniolite. Amer. Journ. Sci., 1900, ser. 4, vol. x, p. 324, abstract (Tæniolite). The same as tainiolite (Flink, 1901).

Tamanite. S. P. Popoff, Zeits. Kryst. Min., 1903, vol. xxxvii, p. 267. The same as anapaite (q.v.). Professor Groth, in an editorial footnote (l. c.), calls attention to this identity, but he gives no reason for admitting the later name as a synonym. Named from the locality, Taman peninsula, Black Sea.

Terlinguaite. W. H. Turner, Mining and Scientific Press, San Francisco, July 21, 1900. Yellowish-green crystals on the mercury-ores of Terlingua, Brewster Co., Texas, determined by S. L. Penfield to be an oxychloride of mercury.

A. J. Moses (Amer. Journ. Sci., 1903, ser. 4, vol. xvi, p. 253) distin-

guishes two oxychlorides of mercury from this locality, which he names eglestonite (q. v.) and terlinguaite. The latter name is applied to monoclinic crystals having the composition Hg_2ClO; these are sulphur-yellow, and alter to olive-green on exposure to light.

Termierite. G. Friedel, Bull. Soc. franç. Min., 1901, vol. xxiv, p. 6 (Termiérite). A clay, resembling halloysite in appearance, with the formula $Al_2O_3 . 6SiO_2 . 18H_2O$. Associated with kaolinite, etc., France. Named after Professor Pierre Termier, of Paris.

Thelotite. C. E. Bertrand and B. Renault, Bull. Soc. Hist. Nat. Autun, 1892, vol. v, pp. 163, 240 (thélotite). An undetermined carbonaceous constituent of Boghead coal from the Thélots pits at Autun.

Vandiestite. (Author?) Described as probably a new species, but without name, by R. Pearce (Colorado Sci. Soc. Bull., 1898, No. 6, p. 4; Proc. [1902], vol. vi, p. 163). The information here given was reproduced, under the name Von Diestite, in a note by E. Cumenge (Bull. Soc. franç. Min., 1899, vol. xxii, p. 25 *bis*): in abstracts of this note the name Diestit (q. v.) has been used. The form vandiestite is given in a dealer's advertisement (Amer. Journ. Sci., November, 1901). A massive telluride of silver, bismuth, gold, and lead, from Sierra Blanca, Colorado. Named after Mr. P. H. van Diest, of San Luis, Colorado, by whom the mineral was found.

Vanthoffite. K. Kubierschky, Sitz.-ber. Akad. Wiss. Berlin, 1902, p. 407 (Vanthoffit). The results of several analyses of an apparently homogeneous specimen, from the salt deposits of Wilhelmshall near Stassfurt, were plotted as curves, and the compound $3Na_2SO_4 . MgSO_4$ inferred to be present in the mixture of salts. This is colourless, with a vitreous lustre, and a coarsely crystalline structure. Pure material was isolated from another specimen by means of a heavy liquid. The salt $3Na_2SO_4 . MgSO_4$ was afterwards prepared artificially by Professor J. H. van't Hoff, of Berlin, after whom the mineral is named.

Vierzonite. A. de Grossouvre, Bull. Soc. géol. France, 1901, ser. 4, vol. i, p. 432. A. Lacroix, Min. de France, 1901, vol. iii, p. 329. A deposit ('argile à silex') consisting essentially of pulverulent opal, which has been produced by the weathering of Cretaceous beds in the neighbourhood of Vierzon, dép. Cher. The same name has been previously applied to a yellow ochreous clay from the same locality (H. W. Bristow, Glossary of Mineralogy, 1861).

Violaite. E. S. Fedorov, Annales de l'Institut agronomique de

Moscou, 1901, vol. vii, p. 43 (Віолантъ). A strongly pleochroic pyroxene which forms an essential constituent of a rock called kedabekite from the Kedabek copper-mine, Caucasus. Differs from fedorovite (Viola, 1899) in having a considerable portion of the magnesia replaced by ferrous oxide. Named after Dr. Carlo Viola, of Rome.

Von Diestite. *See* vandiestite.

Weldite. F. M. Krausé, Proc. Roy. Soc. Tasmania, for 1884, 1885, p. lxxv. A silicate of aluminium and sodium, from the Weld river, upper Huon district, Tasmania.

Wiikite. W. Ramsay. Mentioned, but without name, by W. Ramsay and A. Zilliacus, Öfvers. Finska Vetenskaps-Soc. Förhandl., 1897, vol. xxxix, p. 58. The name wiikite appears in a dealer's advertisement (Amer. Journ. Sci., December, 1899). An euxenite-like mineral found with monazite in a felspar-quarry at Impilaks, Lake Lagoda, Finland. Named after Professor F. J. Wiik, of Helsingfors.

Zeophyllite. A. Pelikan, Anzeiger Akad. Wiss. Wien, Math.-naturw. Cl., 1902, Jahrg. xxxix, p. 113; Sitz.-ber., 1902, vol. cxi, Abth. I, p. 336 (Zeophyllit). A zeolite containing fluorine; $H_4Ca_4F_2Si_3O_{11}$. It occurs at Gross-Priesen, Bohemia, as hemispherical and spherical aggregates of small plates with a perfect cleavage and pearly lustre. Named from ζεῖν, to boil, and φύλλον, a leaf.

Zinc-römerite. R. Scharizer, Zeits. Kryst. Min., 1903, vol. xxxvii, p. 546 (Zinkrömerit). Römerite in which ferrous iron is replaced by zinc. In the natural mineral, from the Harz, this replacement is only partial, but it is more complete in an artificial product.

SYSTEMATIC CLASSIFICATION OF NEW MINERALS[1].

Elements.

Sulfurite, amorphous S.
Arsensulfurite, do. with As.

Sulphide.

Chalmersite, $CuFe_2S_4$.

Tellurides.

Rickardite, Cu_4Te_3.
Speculite, contains Au,Ag.
Vandiestite, contains Ag,Bi,Au,Pb.

Arsenides.

Badenite, $(Co,Ni,Fe)_2(As,Bi)_3$.

[1] Synonyms, names of mixtures, and various indefinite names given in the alphabetical list above are here omitted.

Keweenawite, $(Cu,Ni,Co)_2As$.
Mohawkite, $(Cu,Ni,Co)_3As$.
Stibio-domeykite, $Cu_3(As,Sb)$.
Ledouxite, $(Cu,Ni,Co)_4As$.
Mohawk-algodonite.
Mohawk-whitneyite.
Semi-whitneyite.

Sulpharsenites, &c.

Liveingite, $Pb_5As_8S_{17}$.
Baumhauerite, $Pb_4As_6S_{13}$.
Seligmannite, $CuPbAsS_3$?
Histrixite,
$7Bi_2S_3 . 2Sb_2S_3 . 5CuFeS_2$?
Antimon-luzonite, $Cu_3(As,Sb)S_4$.

Haloids.

(Mercuric iodide)[1], HgI.
Iodembolite, Ag(Cl,Br,I).
Terlinguaite, Hg_2ClO.
Eglestonite, Hg_6Cl_3O.
Petterdite, oxychloride Pb.
Koenenite,
$Al_2O_3 . 3MgO . 2MgCl_2 . 6H_2O$.

Oxides.

(Cadmium oxide)[2], CdO.
Montroydite, HgO.
Lardite, var. of opal.
Vierzonite, „ „
Hydrogöthite, $3Fe_2O_3 . 4H_2O$.
Esmeraldaite, $Fe_2O_3 . 4H_2O$.
Brostenite, near chalcophanite.

Carbonates.

Erzbergite, calcareous sinter.
Manganosphaerite,
$3FeCO_3 . 2MnCO_3$.
Synchysite, $CeFCa(CO_3)_2$.
Artinite, $MgCO_3 . Mg(OH)_2 . 3H_2O$.
Plumbomalachite,
$2CuCO_3 . Cu(OH)_2 . PbCO_3$.
Melanochalcite,
$Cu_2(Si,C)O_4 . Cu(OH)_2$.

Anhydrous Silicates.

Pigeonite, var. of pyroxene.
Violaite, „ „
Kunzite, violet spodumene.
Bourgeoisite, $CaSiO_3$?
Eisencordierit, var. of cordierite.
Kalkeisencordierit, „
Hackmanite, sodalite group.
Bleizinkchrysolith, $PbZnSiO_4$ (artificial).
Hellandite,
$2CaO . 3(Ce,Al,\&c.)_2O_3 . 4SiO_2$.
Serendibite,
$10(Fe,Ca,Mg)O.5Al_2O_3.6SiO_2.B_2O_3$.
Grandidierite, contains Al,Fe,Mg, Ca.

Hydrous Silicates.

Macrolepidolite, var. of lepidolite.
Microlepidolite, „ „
Natronphlogopit, var. of phlogopite.
Pyknochlorite, near clinochlore.
Brunsvigite, near metachlorite.
Lassallite,
$3MgO . 2Al_2O_3 . 12SiO_2 . 8H_2O$.
Termierite, $Al_2O_3 . 6SiO_2 . 18H_2O$.

[1] A. J. Moses, Amer. Journ. Sci., 1901, ser. 4, vol. xii, p. 98; Zeits. Kryst. Min., 1902, vol. xxxv, p. 417. Minute scarlet crystals, probably cubic, from Broken Hill, New South Wales.

[2] B. Neumann & E. Wittich, Chemiker-Zeitung, 1901 (July), Jahrg. xxv, p. 561; E. Wittich & B. Neumann, Centralblatt Min., 1901 (September), p. 549; abstract, this vol., p. 308. Cubic octahedra from Monte Poni, Sardinia.

Lotrite,
$3(Ca,Mg)O . 2Al_2O_3 . 4SiO_2 . 2H_2O$.
Bavenite, $3CaO . Al_2O_3 . 6SiO_2 . H_2O$.
Molybdophyllite,
$2(Pb,Mg)O . SiO_2 . H_2O$.
Bakerite, $8CaO . 5B_2O_3 . 6SiO_2 . 6H_2O$.

Zeolites.

Chromocyclite, var. of apophyllite.
Zeophyllite, $H_4Ca_4F_2Si_3O_{11}$.
Pseudophillipsite,
$(Ca,Na_2)_2Al_4Si_5O_{18} . 9H_2O$.
Pseudomesolite, near mesolite.
Mooraboolite, near natrolite.
Silver-analcite, &c. (artificial).
Ammonium-analcite, &c. „

NIOBATES, &c.

Neotantalite.
Wiikite, near euxenite.

PHOSPHATES, &c.

Anapaite, $FeCa_2(PO_4)_2 . 4H_2O$.
Ceruleite,
$CuO . 2Al_2O_3 . As_2O_5 . 8H_2O$.
Schertalite,
$Mg(NH_4)_2H_2(PO_4)_2 . 4H_2O$.
Stoffertite, $HCaPO_4 . 2\frac{3}{4}H_2O$.
Hörnbergite, uranium arsenate.

SULPHATES.

Ciempozuelite, $3Na_2SO_4 . CaSO_4$.
Vanthoffite, $3Na_2SO_4 . MgSO_4$.
Natroalunite,
$(Na,K)_2[Al(OH)_2]_6(SO_4)_4$.
Natrojarosite,
$Na_2[Fe(OH)_2]_6(SO_4)_4$.
Plumbojarosite,
$Pb[Fe(OH)_2]_6(SO_4)_4$.
Ferropallidite, $FeSO_4 . H_2O$.
Boothite, $CuSO_4 . 7H_2O$.
Natronkalisimonyit, near blödite.
Palacheite,
$2MgO . Fe_2O_3 . 4SO_3 . 15H_2O$.
Zinc-römerite,
$(Fe,Zn)SO_4 . Fe_2(SO_4)_3 . 14H_2O$.

HYDROCARBON.

Thelotite.

September, 1903.

NOTES.

We regret to record the deaths of the following mineralogists:—

Alphonse François Renard (1842–1903), Professor of Mineralogy and Geology in the University of Ghent. He was an honorary member of this Society, and was well known in England both personally and by reason of his work on deep-sea deposits and petrology in the 'Challenger' reports.

Albert Huntington Chester (1843–1903), Professor of Chemistry and Mineralogy in Rutgers College, New Brunswick (New Jersey). His extremely valuable 'Dictionary of the Names of Minerals,' published in 1896, will keep his name long in the minds of mineralogists. He had been a member of this Society since 1887.

Luigi Bombicci-Porta (1833–1903), since 1860 Professor of Mineralogy in the University of Bologna. He was a prolific writer on mineralogical subjects.

Johann Theodor Lemberg (1842–1903), Professor of Mineralogy and Geology in the University of Dorpat. The chemical action of reagents on silicates and the micro-chemical examination of minerals were his special studies.

A famous collection of minerals, which till now has remained in the possession of the Rashleigh family at Menabilly, Cornwall, has recently (1903) been acquired, partly by presentation and partly by purchase, by the Museum of the Royal Institution of Cornwall at Truro, the principal donor being Mr. J. D. Enys. The collection is particularly rich in rare old Cornish minerals, and many of the specimens are unique. A quarto volume of coloured plates with brief descriptions—'Specimens of British Minerals selected from the cabinet of Philip Rashleigh'—was published in 1797 and 1802, and contains the earliest descriptions extant of certain well-known Cornish minerals, for example, bournonite and connellite.

The private collection of South American minerals brought together by the late Theodor Hohmann (1843–1897), of Chile, after whom the mineral hohmannite receives its name, has been sent to this country for sale, and a large selection has been made for the British Museum. Specially noteworthy are fine crystallized specimens of rare minerals from Sierra Gorda in Chile, namely, percylite, atacamite, caracolite, paralaurionite, schwartzembergite, &c., the last named being in well-developed tetragonal crystals.

An authors' catalogue and subject index of mineralogical (including petrological and crystallographic) books and papers published in 1901 has been issued as one of the volumes of the International Catalogue of Scientific Literature. With the subject-key in four languages and a list of journals indexed, the volume extends to 208 pages. Owing to the difficulties of organizing the work, the index is very incomplete, there being only two parts of 'Groth's Zeitschrift' included, and none of the 'Centralblatt für Mineralogie, &c.,' or 'Tschermak's Mineralogische Mitteilungen'; on the other hand, German technical journals have been very fully dealt with. Economic literature, indeed, has been indexed much more fully than the scope originally intended for the catalogue would warrant, but this may possibly add to its usefulness. The topographical arrangement of both scientific and economic titles will certainly be found of use.

A complete and fully illustrated treatise on the regular intergrowth of minerals of different species is given by Professor O. Mügge in the 'Neues Jahrbuch für Mineralogie, &c.' (1903, Beil.-Bd. xvi, pp. 335–475, with 82 figs.). The labour of compilation must have been considerable, and have involved an exhaustive search of mineralogical literature, for the facts here brought together are in many cases mentioned only casually in papers. The tabular classification and index now given will greatly facilitate reference to the subject. Seventy-two well-established cases of regular intergrowth are described in detail, while many more receive mention. A general discussion of the subject is appended.

Another paper, covering much the same ground, was published a few months earlier (F. Wallerant, Bull. Soc. franç. Min., 1902, vol. xxv, pp. 180–222, with 26 figs.).

REVIEWS.

Mineralogy: an Introduction to the Scientific Study of Minerals. By Henry A. Miers, D.Sc., M.A., F.R.S. Pp. xviii + 584, with two coloured plates and 716 illustrations in the text. (London: Macmillan & Co., Ltd., 1902. Price 25*s.* net.)

Since the study of minerals must be conducted by means of their chemical, physical, and morphological characters, it follows that it can

only be successfully undertaken by those already tolerably grounded in the elements of chemistry, physics, and crystallography. The recognition of this fact has led to the preparation of numerous treatises possessing the common feature of an elaborate introduction in which the student is provided with all that it is considered necessary for him to know of cognate branches of science. Among the most widely circulated and successful of the attempts made in this direction the 'Text-Book of Mineralogy' by Professor E. S. Dana has taken an honourable place, and English-speaking students are now to be congratulated on the possession of another excellent handbook following much the same lines.

The work before us is divided into two parts of approximately equal length. The first hundred pages of Part I are devoted to the definition of a crystal and to the exposition of the fundamental laws of crystallography, and include a description of the characteristic properties of the thirty-two crystal sub-classes. The next hundred pages deal with the measurement of crystals and with their optical properties. The remaining chapters of Part I are occupied by an account of the chemical principles involved in mineral analysis, and include also a discussion of isomorphism, definitions of the terms, such as hardness, lustre, &c., used in describing minerals, and directions for performing simple chemical tests. Two appendices conclude this part of the book, and contain a synopsis of the thirty-two crystal sub-classes and a very brief outline of the theory of crystal structure.

In an elementary work of this kind no great originality of treatment is to be looked for, nor is indeed possible, when the author is dealing with branches of science in which the main tracks are already so clearly marked out, and when his aim, from the nature of the case, must be chiefly directed to securing as much compression as is consistent with clearness of exposition. Nevertheless, there are several features in this book which claim special attention. In the first place all crystallographers, however little they may be disposed to accept his suggestions, must feel grateful to Professor Miers for his efforts to reduce to order the names of the thirty-two crystal sub-classes. A system of nomenclature elaborated by the author in consultation with Professor Dana cannot fail to claim respect, if indeed it does not carry conviction to all, though doubtless there will be found some to regret the fusion of the rhombohedral with the hexagonal system. Another interesting and novel feature is the application of colour-photography to the delineation of the optical phenomena presented by crystal-sections. A glance at the two plates at the end of the book will cause the reader to regret that con-

siderations of expense prevented the wider application of the process. A third point worthy of attention is the completeness of the work. In it an account will be found, brief it may be, of all the essential properties of crystals. This feature is at once both the strength of the book and also a source of weakness, for it is inevitable that obscurities must occur when subjects which might fitly demand a treatise in themselves are dealt with in the course of a hundred pages. Thus the chapter on optics will be found difficult reading by the elementary student; it seems indeed doubtful if the most attentive perusal will give him accurate ideas as to the polarization produced when light is reflected and refracted by a plate of glass, or as to the cause of the colour-phenomena exhibited by thin crystal-plates viewed in parallel white light between crossed nicols.

While in Part I Professor Miers has achieved all the success that the difficulty of his task permitted, it is in Part II, which deals with descriptive mineralogy, that we find the freshness of treatment which differentiates this book from all others of its class. Too often descriptive mineralogy is treated as a catalogue of the driest facts presented in bewildering number to the eye of the disheartened learner, who is speedily wearied and finally repelled. Professor Miers has chosen a more excellent way. He concentrates the beginner's attention on one or two of the more important and characteristic occurrences of each mineral species, and brings them vividly before his eye, not merely in the shape of the ideal figures of the crystallographer, but also by means of the admirable series of sketches drawn from actual specimens which we owe to the skilful pencil of Miss J. Miers. Where all are so good it is difficult to single out any for special praise, but attention may be called to the drawings of cassiterite and of microcline (pages 361 and 460). A comparison of these pictures with the photographs of calcite, on pages 397 and 398, will speedily convince the most sceptical that there are regions in which the camera cannot compete with the seeing eye and the well-trained hand. No attempt has been made to deal in detail with the rarer minerals, but they are duly inserted in the most valuable tables, last in place but by no means in importance, with which the book concludes. Here we find the minerals arranged according to their chemical composition, and also in order of their refractive indices, birefringences, optic axial angles, and specific gravities. The printer has done his part admirably; there is an excellent index, and the appearance of the book leaves nothing to be desired. It will be found invaluable by teacher and student alike.

The Diamond Mines of South Africa: some account of their rise and development. By Gardner F. Williams, M.A., General Manager of the De Beers Consolidated Mines, Ltd. Pp. xviii + 681. Royal 8vo. (New York: The Macmillan Company; London: Macmillan & Co., Ltd., 1902. Price £2 2*s.* = $10.00 net.)

This handsomely got up and profusely illustrated volume contains much that will be of interest to the general public, and being written by the General Manager of the De Beers Consolidated Mines, may be regarded as authoritative when dealing with the operations of this influential Company. Much, however, of the matter contained in the book, though interesting in itself, has little or no direct bearing on the subject indicated in the title. On the other hand, very little is said of those diamond mines of South Africa not directly controlled by the De Beers Company, some indeed being not even mentioned.

The first 119 pages are devoted to a general discourse on the diamond, its mention in ancient writings, the stories associated with famous stones, the discovery and opening up of South Africa, and finally the finding of diamond there in 1867. Then follow graphic accounts of the diggings on the Vaal River and the early workings at Kimberley. A very full and detailed description, based largely on the author's personal observations, is given of the later workings, both open and underground, in the De Beers and Kimberley mines, and of the methods employed in extracting the diamond from its matrix. The book concludes, as it began, with 120 pages or so of more or less irrelevant matter dealing with the cutting of diamond, the opening up of the gold-fields of South Africa, and the siege of Kimberley in the late Boer war.

Practically all the volume contains of special mineralogical interest is confined to the chapter on the formation of the diamond. The author holds the view that the diamond-bearing 'blue-ground' is of aqueous rather than of igneous origin, and was erupted into the pipes by mud volcanoes, a view which is supported by the fact that the shales surrounding the pipes and caught up by the 'blue-ground' have not been in the least altered. As to the origin of the diamond, he favours no particular theory, but raises objections to all that have been brought forward, including that which supposes the diamond to have crystallized from a basic silicate-magma, and which has been proved to be practically possible by the experiments of Friedländer (1898), experiments, however, which receive no mention in the book. The author's chief objection to the view just mentioned seems to be based on Luzi's observation that

crystals of diamond are corroded by molten 'blue-ground.' It might be equally well urged that crystals of salt, being corroded by water, are therefore incapable of separating out from an aqueous solution. It is, however, a notable fact that diamond has never been found enclosed in olivine or in any other mineral, and the intimate association or intergrowth of diamond with other minerals appears to be of extremely rare occurrence. In this connexion a case is here recorded of a diamond enclosing a small octahedron of diamond and some white plates of apophyllite.

The mineralogical information is on the whole unsatisfactory, and contains many minor inaccuracies: for example, the figures of diamond crystals, on p. 534. The technical side relating to the methods of mining and washing might also have been much more complete. The book is popular in style, and its most striking feature is the wealth of illustrations, which include several excellent photogravures. These, however, are not arranged with regard to the accompanying text, and in some cases have no reference to it whatever. Several ancient maps of the African continent are given, and a plan of the De Beers group of mines at Kimberley, but no map to illustrate the distribution of diamond in South Africa.

Mathematical Crystallography and the Theory of Groups of Movements. By Harold Hilton, M.A. Pp. xii + 262, with 188 figures in the text. (Oxford: at the Clarendon Press, 1903. Price 14*s.* net.)

The British Association Report on 'The Structure of Crystals' (1901) gives a full historical account of the development of the geometrical theory; but such a survey is necessarily lacking in detailed reasoning. The gap is now filled by Mr. Hilton's admirable book. Its scope is perhaps more accurately indicated by the subsidiary than by the main title, since it is almost wholly concerned with the symmetry and structure of crystals. Although in his preface the author modestly disclaims any originality, and points out that in Part II (and to some extent, we may remark, in Part I also) he follows the lines of Schönflies's 'Krystallsysteme und Krystallstructur,' adopting here and there features from the writings of Barlow, Jordan, and Fedorow, the book is by no means a slavish copy of the original. A great improvement is effected by the excellent diagrams of the space-groups, which have been independently drawn on the methods suggested by Fedorow. The absence of such diagrams in Schönflies's book undoubtedly adds greatly to the difficulty of following his reasoning. Mr. Hilton might with advantage have pointed out that underlying each of the 230 groups there is, besides the

lattice, a Sohncke-system. Many readers, who have had no previous acquaintance with the theory of groups, might find this (Barlow's) method the easiest way of approaching the subject.

Part I is mainly occupied with the derivation of the thirty-two point-groups, which obey the law of rational indices and are therefore alone applicable to crystals. It also contains an interesting chapter on the growth of crystals. It seems indeed probable that it is by means of observations on growing crystals that the elusive clue to the problem of the connexion between crystal form and chemical composition will eventually be found. The sequence adopted in Part II is precisely that of Schönflies: after establishing the fourteen lattices, Mr. Hilton discusses the properties of geometrical operations, and proves the fundamental proposition that each space-group is isomorphous with one of the thirty-two point-groups and all the operations of the point-group are symmetry-operations of some space-lattice. The systematic application of this property determines the 230 groups. Towards the end of the book is a discussion of the partitioning of space and of Schönflies's elementary cell. Mr. Hilton has indeed handled with ease and skill a subject which, like all dealing with three dimensions, is with difficulty rendered intelligible. We must not omit a word of commendation to the Delegates of the Press for their enterprise in publishing a book which can appeal only to a limited few, and for the excellent way in which the printing has been executed.

Ueber Harmonie und Complication. Von Dr. Victor Goldschmidt. Pp. iv + 136, with 28 figures in the text. (Berlin: Julius Springer, 1901.)

Perhaps the most marked feature of recent development of science is the tendency to remove the artificial barriers between the various branches and the merging of the one into the other at their mutual boundaries. Any attempt to co-ordinate the principles underlying the different subjects cannot fail to be of interest, even if not convincing. At first sight it might indeed appear absurd to imagine any possible connexion between subjects so different as crystallography, music, and spectrum analysis; nevertheless a perusal of Professor Goldschmidt's book will convince the careful reader that the co-ordination which he traces is not to be idly dismissed.

Professor Goldschmidt's name is well known to crystallographers. For some years past he has published in the 'Zeits. für Kryst. und Min.' papers dealing with the law of complication, as he interprets Haüy's

crystalline law, in the course of which he shows that the symbols which may be assigned to crystal faces fall into certain groups. This law forms the basis of the present work and is explained in the opening pages. We will quote the following table :—

Primary faces :	A							B	= Normal row 0.
N_0 =	0							∞	
1 complication :	A			C				B	= Normal row 1.
N_1 =	0			1				∞	
2 complication :	A		D	C		E		B	= Normal row 2.
N_2 =	0		$\frac{1}{2}$	1		2		∞	
3 complication :	A	F	D	G	C	H	E	I	B	= Normal row 3.
N_3 =	0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	$\frac{3}{2}$	2	3	∞	

A, B, C, &c., represent faces lying in the same zone, and the numbers underneath each represent the corresponding indices, which have been arithmetically transformed so as to make the extremes 0 and ∞ instead of, as usual, 0 and 1. Professor Goldschmidt asserts that, if A, B, and C are properly selected, we obtain a series of groups [DE], [FGHI], &c. The faces become rarer as the symbol increases in complexity, and those in each group are likely to appear together. Each of the rows is derived from the preceding in precisely the same way. Thus 0 1 ∞ can be transformed into 0 $\frac{1}{2}$ 1 and 1 2 ∞. The indices of commonly occurring faces rarely exceed those given by the third complication.

Similar series may be obtained from the pitch numbers of the notes constituting a musical scale. Thus in the case of the major scale of C we have :—

c	*d*	*e*	*f*	*g*	*a*	*b*	$\bar{c}$
1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2
0	$\frac{1}{7}$	$\frac{1}{3}$	$\frac{1}{2}$	1	2	7	∞

where the last row is obtained from the preceding by arithmetical transformation. Two notes, *d* and *b*, have numbers higher than those given by the third complication. These must be excluded because, as the author very plausibly remarks, they really belong to the chord of the dominant, *g*, being respectively the fifth and the third. The third complication gives the following scale :—

c	*e*	*f*	*f*♯	*g*	*a*♭	*a*	*b*♭	$\bar{c}$
1	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{7}{5}$	$\frac{3}{2}$	$\frac{8}{5}$	$\frac{5}{3}$	$\frac{7}{4}$	2
0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	$\frac{3}{2}$	2	3	∞

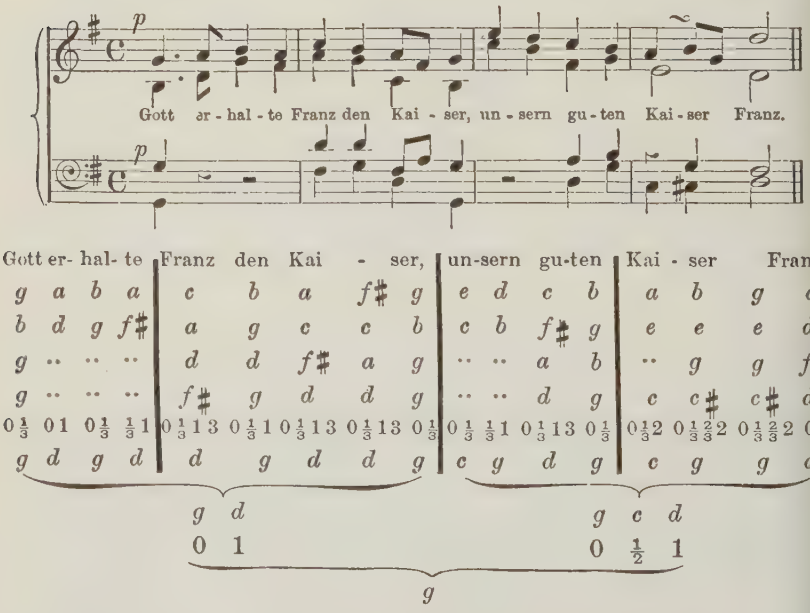
b♭ forms the modulation to the chord of the sub-dominant and is of

great importance in the key of C. The remaining pair are not of such frequent occurrence. The author remarks that often in crystals and in colour phenomena the development lies between two normal rows. It is a remarkable discovery that the minor scale is, so to speak, the reflection of the major; thus we have:—

Rising harmony, major scale: $c \quad e \quad f \quad g \quad a \quad \bar{c}$
$0 \quad \frac{1}{3} \quad \frac{1}{2} \quad 1 \quad 2 \quad \infty$

Falling harmony, minor scale: $\bar{c} \quad a\flat \quad g \quad f \quad e\flat \quad c$
$0 \quad \bar{\frac{1}{3}} \quad \bar{\frac{1}{2}} \quad \bar{1} \quad \bar{2} \quad \bar{\infty}$

The development from other ground-tones selected from the scale is discussed and the resulting tones are compared with those belonging to the original scale. Equal temperament is touched upon and its justification pointed out. Certain examples of classical music are studied in detail. As an instance of his method, we quote his analysis of Haydn's well-known hymn:—



Thus it will be seen that no numbers occur exceeding those given by the third complication.

In the next chapter will be found an interesting discussion of the physiological and psychological grounds for the harmony of tones.

Helmholtz was of opinion that Corti's organ renders possible the discrimination of sounds; but, as Professor Goldschmidt points out, it is difficult to account in this way for the almost infinite gradations of tone that are appreciable by an educated ear. He himself thinks that the tympanum plays an important part. The appreciation of musical sounds, as apart from noise, depends on the brain; that there is some connexion is shown by the fact that we can think and dream of tones.

An exceedingly interesting chapter is that dealing with the harmony of colours. The author shows that the wave-lengths of the principal Fraunhofer lines, with the exception of G, agree with the third complication, and that the same is true of the hydrogen lines. The occurrence of the octave in the lines of the spectra of the elements has frequently been observed; the idea that they form an harmonious series is suggestive and worthy of further study. The author discusses fully the various theories of colour vision, especially that of Young and Helmholtz. The exhaustive history of the development of colour vision testifies to his painstaking research. Recent work among the primitive races still existing confirms the correctness of his view, that in early days man possessed little discrimination of colour.

The book closes with a discussion of other evidence of the law in nature, such as is given, for instance, by the characters of organisms, by the systems of numbers, by the monetary systems, and so on. It is however impossible within the limits of a review to enter into these in detail.

Professor Goldschmidt may be congratulated on the production of a thoughtful and philosophical work. Ranging, as it does, over such a diversity of subjects, it is indeed a formidable task to be attempted single-handed. Whether the views expressed are correct or not, it is in the present state of our knowledge perhaps impossible to decide. There can, however, be no doubt as to the value of such a book in calling attention to, and throwing light on, the possibility of the co-ordination of fundamental principles.

ABSTRACTS.

Ueber den Einfluss der Lösungsgenossen auf die Krystallisation des Calciumcarbonates (Heinrich Vater, in Tharandt, Saxony), Zeits. Kryst. Min., 1893-9, vol. xxi, pp. 433-490; xxii, 209-228; xxiv, 366-404; xxvii, 477-504; xxx, 295-298, 485-508; xxxi, 538-578).

Part I.—The aim of these researches is to throw light on the conditions which determine the 'habit' of crystals, with the ultimate object of enabling us to prepare minerals artificially in the forms which they exhibit in their various occurrences, and so to lay a foundation on which conclusions as to their modes of formation in nature may be based. Owing to the number of its forms, its dimorphism, and its wide distribution, calcium carbonate was selected for study, and the influence on its crystallization of other substances present in solution at the time of its deposition (co-solutes) was investigated.

From a consideration of the work of his predecessors, of which he gives an historical summary, the author was led to investigate first the deposition of $CaCO_3$ at ordinary temperatures from solution in water containing CO_2, and found that the sole product was calcite in fundamental rhombohedra, *R*. The study of the influence of co-solutes was next begun. It was found that the best crystals were got by diffusion, and after preliminary experiments the following method was adopted. A dish 85 mm. in diameter and 40 mm. high was placed inside another 135 mm. in diameter and 60 mm. high; one-fifth gram-equivalent of a soluble calcium salt and of an alkaline bicarbonate were dissolved in small quantities of water saturated with CO_2 and placed in the inner and outer dishes respectively, the dishes were then filled up with water saturated with CO_2, covered, and diffusion allowed to go on. Under these conditions the crystallization of the $CaCO_3$ proceeds under the influence of the soluble salt formed by the action of the bicarbonate on the calcium salt. If it was desired to increase the amount of the co-solute, or to study the effect of some other foreign substance, the necessary compounds were added to the water. After some days crystals separated, chiefly round the small dish—inside it towards its rim (these are usually the best), outside it, on its bottom, and clinging to the water surface above it.

Experiments made as above, using $CaCl_2$ and $Ca(NO_3)_2$ with $KHCO_3$ and $NaHCO_3$ respectively, gave calcite only, showing combinations of

the forms R and steep negative rhombohedra $-mR$ (measurable in some cases, $-6R$ being common). The addition of KCl or NaCl to the water merely altered the value of m. On using stronger solutions of $CaCl_2$ and of $KHCO_3$ crystals in the form $-mR$ were found, m being greatest for crystals deposited furthest from the inner dish. Experiments with $CaCl_2$ and $KHCO_3$ in which gypsum was added to the water gave calcite only, with $-mR$ largely developed. Addition of a small quantity of $BaCl_2$ to the solution produced mixed crystals containing up to 9% $BaCO_3$, and having the form of calcite ($-mR$ with base). Hemispherical aggregates composed of radially arranged fibres were also formed. The optical behaviour of these fibres suggests that they are anorthic or oblique, they contain $BaCO_3$ in small quantities, are converted into calcite when heated to low redness, their sp. gr. is 2·56, and they are believed by the author to be a new form of calcium carbonate.

Two further series of experiments were made by adding $CaCl_2$, $Ca(NO_3)_2$, $KHCO_3$, $NaHCO_3$, KCl, NaCl, KNO_3, and $NaNO_3$ respectively, in quantities of one-fifth gram-equivalent per litre, and of one gram-equivalent per litre, to water saturated with $CaCO_3$ and CO_2. On allowing to stand at 5°–18° C. crystals similar to those got by diffusion and exhibiting R and $-mR$ were obtained.

From these experiments the author concludes that R is the form in which calcite crystallizes from pure solutions, the occurrence of other forms depending on the presence of co-solutes; the development of a particular form depending further on the nature and concentration of the co-solutes and on the velocity of crystallization.

II.—Since G. Rose and Credner both state that a solution of $CaCO_3$ in water containing CO_2 which deposits calcite at first, yields aragonite on standing, the author made a careful study of the crystallization of $CaCO_3$ under these conditions. Preliminary experiments in which the calcite formed was filtered off, and in which drops of solutions of various strengths were allowed to evaporate, gave only rhombohedra of calcite when dilute solutions were used, and calcite crystals together with disc-like bodies when the solutions were stronger. Next ten solutions were prepared, containing from 0·5 to 0·05 gram of $CaCO_3$ per litre, and these allowed to evaporate at temperatures of from 5° to 20° C. The product in all cases was calcite in the form R. The crystals deposited after long standing showed traces of modifications probably due to the influence of silicates dissolved from the glass vessels, as a solution made with water previously boiled in a glass vessel behaved similarly. Certain rod-like bodies found in some of the solutions, and thought at first to be

aragonite prisms, proved to be bacteria. These results do not confirm the statements of Rose and Credner.

III.—In some of the diffusion and evaporation experiments described in Part I, exceptionally large crystals of a yellow colour were found on the bottom of the small dish. The colour was traced to organic matter, probably derived from the alkaline bicarbonate. On repeating the experiments with fresh chemicals no such crystals were obtained except when K_2SO_4 (a substance specially liable to be contaminated by organic matter) was added as a co-solute.

IV.—Since Rose stated that aragonite was produced both on evaporation at ordinary temperatures of water containing $CaCO_3$ and CO_2, and also when solutions of $CaCl_2$ and Na_2CO_3 were allowed to diffuse, and as the author's experiments so far described are not in accordance with these statements, a careful repetition of the diffusion experiments was undertaken. Pure solutions of $CaCl_2$ and of Na_2CO_3 were allowed to diffuse into one another in the presence of much water in such quantity that only a little $CaCO_3$ was formed; this proved to be calcite. In one experiment sheaf-like crystal aggregates and round discs were found as well as good crystals of calcite. The aggregates are tinted yellow by organic matter, they are built up of fibres giving straight extinction, consist of $CaCO_3$, and have the sp. gr. of calcite. The author thinks that the presence of organic matter causes the production of these fibrous aggregates, and believes that Rose mistook them for aragonite.

V.—The disc-shaped crystallites of $CaCO_3$ have already been observed by Link, Rose, and others. The author met with them often in the crystalline crust formed on the surface of the liquid when water containing $CaCO_3$ and CO_2 was evaporated. The discs are formed at the same time as the crystals of calcite, and frequently redissolve as evaporation proceeds. They are usually colourless and consist of $CaCO_3$. The sp. gr. is a little lower than that of calcite. The addition of various co-solutes had no influence on their formation, but they were deposited most readily from strong solutions of $CaCO_3$ containing but slight excess of CO_2. Though the author has been unable to trace the cause of their production with certainty, he attributes it to the presence of slight traces of some unknown impurity in the $CaCO_3$ from which the solution was prepared.

VI.—The experiments described in this section show that unless the concentration of a co-solute exceeds a certain value it has no effect on the crystallization. Thus the presence of 0·005 gram-equivalents of NaCl per litre has no effect on the deposition of calcite, which crystal-

lizes in fundamental rhombohedra R, whereas the influence of 0·13 gram-equivalents is decided, the crystals showing the forms R with $-mR$ ($m = 8$). The author concludes, moreover, that there is also an upper limit beyond which the further addition of the co-solute produces no effect.

VII.—As Credner reported the formation of aragonite as well as of calcite on the evaporation of water containing $CaSO_4$ in addition to $CaCO_3$ and CO_2, the author studied the influence of various sulphates present as co-solutes. Calcite only was formed on allowing a solution of an alkaline bicarbonate to diffuse into a calcium solution containing Na_2SO_4. On evaporating solutions of $CaCO_3$ in water containing CO_2, and to which various quantities of $CaSO_4$ had been added, calcite only was obtained. The crystals from solutions containing but little $CaSO_4$ were rhombohedra R. As the amount of $CaSO_4$ increased, the form of the crystals changed, $-mR$ appearing, the value of m increasing as more $CaSO_4$ was added. Similar results were got on adding K_2SO_4 instead of $CaSO_4$, the basal plane appearing as well as the form $-mR$. Addition of Na_2SO_4 produced the same results; when added in small quantity no effect could be detected, but as the amount increased, planes of the form $-mR$ appeared, and when much was added, the crystals had the form of prisms terminated by faces of the form R. It has been shown in Part I that the presence of the bicarbonates of K, Na, and Ca has no influence on the form of the crystals deposited, hence the modifications just described are to be attributed to the presence of the SO_4 ion. Moreover the influence of the co-solute seems to be greater the more slowly crystallization takes place.

VIII.—A series of experiments was undertaken to investigate the action of the carbonates and bicarbonates of K and Na on gypsum. The product in all cases was calcite, not aragonite. This is in direct opposition to Becquerel's statement that aragonite can be formed at ordinary temperatures by the action of $NaHCO_3$ on gypsum, and therefore his conclusion, that the presence of $CaCO_3$ as aragonite in gypsum deposits was due to the action of the latter, cannot be maintained. Similar experiments on anhydrite led to the same results, and a discussion of the pseudomorphs of $CaCO_3$ after gypsum and anhydrite, leads the author to the conclusion that 'schaumkalk' is the only authentic instance of aragonite pseudomorphous after gypsum. Hence Rose's statement that aragonite is not formed at temperatures below 30° C. is amply confirmed by the author's researches. A. H.

Cylindrical Cleavage of Gypsum and Anthophyllite (G. Friedel, Bull. Soc. franç. Min., 1902, vol. xxv, pp. 102–10).—In addition to the perfect cleavage parallel to the plane of symmetry, gypsum is usually stated to possess a fibrous cleavage parallel to the faces of the pyramid $n\{\bar{1}11\}$, and a conchoidal cleavage parallel to the orthopinacoid $a\{100\}$. On the goniometer, however, the fibrous cleavage gives a perfectly continuous band of reflected images in the zone $[\bar{1}11, \bar{1}\bar{1}1]=[101]$, with only slightly brighter portions corresponding to the positions of the planes $(\bar{1}11)$ and $(\bar{1}\bar{1}1)$. There are thus no plane cleavages parallel to these faces, but, on the other hand, a linear or, more correctly, a cylindrical cleavage parallel to the zone-axis [101], this being a direction of maximum cohesion and reticular density in the crystal. The conchoidal cleavage of gypsum is also not a plane cleavage, but a cylindrical cleavage parallel to the zone-axis [001], though less perfectly developed than the cylindrical cleavage parallel to [101].

In the same way anthophyllite possesses a prominent cylindrical cleavage parallel to the prism-edge [001], and only traces of plane cleavages parallel to the faces of the prism $m\{110\}$ and brachypinacoid $b\{010\}$. L. J. S.

Production of Iceland-spar and Cryolite. The following details are taken from a statement of the mineral productions of Denmark and its possessions for the year 1900 (N. V. Ussing, Danmarks geol. Unders., 1902, ser. 2, No. 12, 118 pages and map).

Iceland-spar. The celebrated quarry[1] is situated in a vein of basalt close to the farm Helgustaðir, and about an hour's ride from the trading station of Eskifjörðr on Reydarfjörðr, on the east coast of Iceland. Since 1895 it has been leased by the Government of the island to T. E. Tulinius of Copenhagen. In recent years a large proportion of the calcite taken out has not been of sufficient transparency for optical purposes, and this has caused a considerable rise in price, which for the best quality amounts to £12 per kilogram. About ten men are employed at the quarry during the summer months, and the annual yield is valued at rather over £280.

Cryolite. The quarry at Ivigtut, on the west coast of Greenland, in lat. 63° 13′ N., is in a mass of cryolite, measuring 500 by 100 feet, which occurs embedded in gneiss. The cryolite usually contains 10 to 30 per cent. of impurities, mainly chalybite.

In 1901 the output amounted to 8,125 metric tons. The total yield

[1] Compare this Magazine, 1890, vol. ix, p. 179.

since 1854 amounts to 307,730 metric tons. The mineral is shipped to Philadelphia and to Copenhagen, and used in the manufacture of opal-glass, enamelled iron, and aluminium. L. J. S.

Epidote crystals from Alaska (Charles Palache, Proc. Amer. Acad. Arts and Sci., 1902, vol. xxxvii, pp. 531–5; and Zeits. Kryst. Min., 1902, vol. xxxvi, pp. 433–7).—Epidote crystals of large size and unusual habit have been found in association with copper-ore in metamorphosed limestone in Prince of Wales Island, Alaska. They are of a dark green to greenish-black colour, but oil-green and translucent in thin crystals. The larger crystals have the form of nearly square tables, flattened parallel to the orthopinacoid, and measure as much as $5\frac{1}{2}$ cm. along the sides and 3 cm. in thickness. In smaller crystals this tabular habit is less pronounced, and these sometimes assume the ordinary prismatic habit of epidote parallel to the axis of symmetry. The crystals are often aggregated in groups of large size, and on them are implanted small, clear crystals of quartz. A detailed crystallographic description, illustrated by a plate of eight figures, is given; twenty-six forms are noted, of which $O\{544\}$ and $j\{755\}$ are new. The crystals are nearly always twinned on the orthopinacoid, and although they often show no re-entrant angles the twinning is readily recognized by the reversal in the direction of the striations on the faces of the clinopinacoid. L. J. S.

The Mica Deposits of India (T. H. Holland, Mem. Geol. Survey, India, 1902, vol. xxxiv, pp. 11–121, with 9 plates).—An interesting account of Indian mica is given under the following main headings:—mineralogical and chemical characters; geological occurrences; geographical distribution; uses; mining practice. The general summary of the mineralogical characters includes new observations on the percussion- and pressure-figures of muscovite. The rays of the pressure-figure intersect at angles of 60°, but the rays of the percussion-figure intersect at angles of 63° and 54°; the principal ray of the latter (which is parallel to the plane of symmetry, and perpendicular to the optic axial plane and one of the rays of the pressure-figure) being inclined to the adjacent rays at 63°. These figures, together with etched figures artificially produced on the cleavage planes, indicate that muscovite is monoclinic, though it may actually be triclinic (as is the case with some other micas) and twinned. The pressure-figure produced at a temperature of about 300° C. has rays intersecting at angles of more nearly 60° (observed 57°, instead of 54° at

ordinary temperatures), and naturally produced pressure- and percussion-figures surrounding enclosures have rays at 30°. It is possible, therefore, that at a higher temperature mica may have a still higher degree of symmetry.

The mica mined in India is practically all muscovite. It occurs in veins of coarsely crystallized pegmatite penetrating the Archaean schists (mainly mica-schists) of the peninsula of India. Owing to the stability of this region and its long freedom from earth-movements, the large crystals of mica have remained unbroken. The principal mining districts are those of Hazáribágh in Bengal, and of Nellore in Madras, but several other localities are noticed. In the Inikúrti mine, Nellore, 'books' of mica measuring 10 feet across the basal planes and up to 15 feet across the folia have been found; rectangular sheets free from cracks and flaws and measuring 30 × 24 inches have frequently been obtained. Bengal mica has usually a ruby tint, while that from Nellore is more often greenish. The output of 131 mines in 1900 amounted to 916 tons. The primitive and wasteful methods of mining are severely criticized, and improvements suggested. L. J. S.

Senaite and Native Zirconia from Brazil (E. Hussak and J. Reitinger, Zeits. Kryst. Min., 1903, vol. xxxvii, pp. 566–579).—Since the publication of the original description of senaite (Min. Mag., vol. xii, p. 30), this mineral has been found to be widely distributed in the diamantiferous sands of the neighbourhood of Diamantina. The following analyses of unaltered crystals give the new formula $(Fe,Mn,Pb,Mg)O.TiO_2$. Senaite is thus isomorphous with pyrophanite, geikielite, and ilmenite.

TiO_2	FeO	MnO	PbO	MgO	ZrO_2	Sp. gr.
52·11	26·97	10·42	10·86	0·32	trace	5 204
50·32	21·99	17·58	9·62	—	0·84	—

Small, brownish or greyish pebbles (the so-called favas) found in the streams of the augite-syenite district of Serra de Caldas, Minas Geraes, consist largely of compact zirconia (ZrO_2, 81·75–93·18 per cent.). It is suggested that this is an alteration product of the zircon present in the augite-syenite. At the same place there also occurs on the weathered syenite a crust with a radially fibrous structure and smooth, shining surface. This has sp. gr. 5·538, and contains ZrO_2, 97·19 per cent.; the optical characters suggest that it is a new modification of zirconia, distinct from baddeleyite. L. J. S.

Chemical composition of Dumortierite (W. E. Ford, Amer. Journ. Sci., 1902, ser. 4, vol. xiv, pp. 426–430).—The following analyses of dumor-

tierite were made with a view to establishing a formula for the mineral: I, material from Clip, Arizona; II, lavender-coloured material from San Diego Co., California; III, from Harlem, New York.

	SiO_2	Al_2O_3	Fe_2O_3	B_2O_3	H_2O	Total	Sp. gr.
I.	29.86	63.56	0.23	5.26	1.41	100.32	3.319
II.	30.58	61.83	0.36	5.93	2.14	100.84	3.226—3.43
III.	31.24	61.26	0.10	6.14	2.09	100.83	3.211—3.392

Regarding the alumina, boron trioxide, and water as bases, there may be deduced from these analyses the acid $H_{60}Si_7O_{44}$; if the hydrogen of this acid be wholly replaced by aluminium, the formula becomes $Al_{20}Si_7O_{44}$, or, written as a basic orthosilicate $(AlO)_{16}Al_4(SiO_4)_7$. In analysis I, in which the ratio of $B_2O_3 : SiO_2 = 1:7$, the formula approximates very closely to $[AlO]_{16}Al_2B_2(SiO_4)_7$. L. J. S.

Chemical composition of Axinite (W. E. Ford, Amer. Journ. Sci., 1903, ser. 4, vol. xv, pp. 195–201).—The following analyses of axinite were made with a view to establishing a formula for the mineral, previous analyses having led to different results and different interpretations: I, crystals of excellent quality from Bourg d'Oisans, Dauphiné, II, material from Obira, Bungo, Japan.

	SiO_2	B_2O_3	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	H_2O	Total.	Sp. gr.
I.	42.78	6.12	17.67	0.99	6.02	2.99	20.16	2.41	1.40	100.54	3.287
II.	41.80	5.61	17.15	1.11	2.84	10.71	19.51	0.21	1.22	100.16	3.028

The new formula deduced from these analyses is expressed as an orthosilicate, $R''_7R'''_4B_2(SiO_4)_8$; the small amount of water, only expelled at a high temperature, is present as basic hydrogen replacing the bivalent bases. L. J. S.

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—		To list of publications of Thomas Davies add :—
		Crystallization and the microscope. Quart. Journ. Microsc. Sci., 1864, new ser. vol. iv, pp. 247-53 ; 1865, vol. v, pp. 205-12.
		Crystallised stephanite and argentite in Cornwall. Geol. Mag., 1866, p. 432.
		Senarmontite from Cornwall. Geol. Mag , 1867, p. 192.

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62	2	*For* he, *read* the.
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97	6*	*For* 1896, *read* 1897.
101	—	*In* Analysis II *add* MgO, 0·26 ; *for* 99·93, *read* 100·19 (total).
102	24–28	*For the paragraph* :—'The acute bisectrix . . . certainty', *substitute* :— The acute bisectrix does not always appear in the centre of the field, and sometimes deviates from it a few degrees in the plane of the optic axes. But by the use of the method described on p. 104, with an isolated rhomb, this deviation has been proved to be due to the uneven nature of the cleavage-flakes and not to a real inclination of the bisectrix to the normal to the face (001).
105	1* (f. n.)	*For* 2E = 70°–74°, *read* 2E = 73°52′ (Na light).
129	3*	*Dele* d_1 211, 36° 12½′, 37° 0′, 1, Minute ; image bad.

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